Fishery Data Series No. 17-31

Sonar Estimation of Salmon Passage in the Yukon River near Pilot Station, 2014

by

Kyle J. Schumann

and

Bruce C. McIntosh

July 2017

Alaska Department of Fish and Game **Divisions of Sport Fish and Commercial Fisheries**

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by the Divisions of Sport Fish and of Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat or long
monetary symbols (U.S.)	\$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$log_{2,}$ etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

FISHERY DATA SERIES NO. 17-31

SONAR ESTIMATION OF SALMON PASSAGE IN THE YUKON RIVER NEAR PILOT STATION, 2014

by
Kyle J. Schumann and Bruce C. McIntosh,
Alaska Department of Fish and Game, Division of Commercial Fisheries, Fairbanks

Alaska Department of Fish and Game
Division of Sport Fish, Research and Technical Services
333 Raspberry Road, Anchorage, Alaska, 99518-1565

July 2017

ADF&G Fishery Data Series was established in 1987 for the publication of Division of Sport Fish technically oriented results for a single project or group of closely related projects, and in 2004 became a joint divisional series with the Division of Commercial Fisheries. Fishery Data Series reports are intended for fishery and other technical professionals and are available through the Alaska State Library and on the Internet: http://www.adfg.alaska.gov/sf/publications/. This publication has undergone editorial and peer review.

Kyle J. Schumann and Bruce McIntosh
Alaska Department of Fish and Game, Division of Commercial Fisheries,
1300 College Rd., Fairbanks, AK, USA

This document should be cited as follows:
Schumann, K. J., and B. C. McIntosh. 2017. Sonar estimation of salmon passage in the Yukon River near Pilot Station, 2014. Alaska Department of Fish and Game, Fishery Data Series No. 17-31, Anchorage.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF APPENDICES

ABSTRACT

The Pilot Station sonar project has provided daily passage estimates for Chinook (*Oncorhynchus tshawytscha*), chum (*O. keta*), and coho (*O. kisutch*) salmon for most years since 1986. Fish passage estimates for each species were generated in 2014 through a 2-component process: (1) estimation of total fish passage with 120 kHz split-beam sonar and a dual-frequency identification sonar, and (2) apportionment to species by sampling with a suite of gillnets of various mesh sizes. An estimated 4,438,214 fish passed through the sonar sampling area between June 3 and September 7. Of those fish, 865,883 passed along the right bank and 3,572,331 passed along the left bank. Included, with 90% confidence intervals, were 103,613 ± 14,963 large Chinook salmon (>655 mm mid eye to tail fork), 34,372 ± 7,931 small Chinook salmon (≤655 mm mid eye to tail fork), 1,924,425 ± 100,258 summer chum salmon, 650,808 ± 63,620 fall chum salmon, 247,047 ± 27,257 coho salmon, 513,599 ± 60,113 pink salmon, and 964,350 ± 83,573 other species.

Key words: Chinook salmon *Oncorhynchus tshawytscha*, chum salmon *O. keta*, coho salmon *O. kisutch*, DIDSON dual-frequency identification sonar, hydroacoustic, split-beam sonar, riverine, sonar, run strength, species apportionment, net selectivity, Yukon River

INTRODUCTION

BACKGROUND

In Alaska, Chinook (*Oncorhynchus tshawytscha*), chum (*O. keta*), and coho (*O. kisutch*) salmon are managed inseason for harvest by commercial, subsistence, and sport fisheries within the Alaska portion of the Yukon River drainage, as well as to meet treaty obligations made under the U.S./Canada Yukon River Salmon Agreement. The diversity and number of fish stocks, combined with the geographic range of user groups, adds complexity to management decisions. Escapement estimates and run-strength indices are generated by various projects within the drainage, providing stock-specific abundance and timing information; however, much of this information is obtained after the fish have become unavailable to the fisheries. Timely indices of run strength are provided by gillnet test fisheries conducted in the Lower Yukon River, but the functional relationship between catch per unit effort (CPUE) and actual abundance is confounded by varying migration patterns through the multi-channel environment, gear selectivity, environmental conditions, and changes in net site characteristics.

The Pilot Station sonar project has provided daily salmon passage estimates, run timing, and biological information to fisheries managers for most years since 1986. The project is located at river km 197 in a single channel environment near the village of Pilot Station. This location is upriver enough to avoid the multiple channel environment of the Yukon River delta. The project is able to provide timely abundance information to managers because travel time for salmon from the mouth of the river to the sonar site is 2 to 3 days (Figure 1). The Andreafsky River is the only major salmon spawning tributary downstream of the sonar site (Figure 2), and therefore the majority of migrating salmon in the Yukon River pass the sonar project on their way to the spawning grounds.

The Alaska Department of Fish and Game's (ADF&G) primary role is to manage for sustained yield under Article VIII of the Alaska Constitution, but Alaska is also obligated to manage Yukon River salmon stocks according to precautionary, abundance-based harvest-sharing principals set forth in the Yukon River Salmon Agreement (Yukon River Panel 2004). The goal of bi-national, coordinated management of Chinook and chum salmon stocks is to meet escapement requirements that will ensure sufficient fish availability for sustained harvests in both the United States and Canada in the future. Furthermore, managers follow guidelines specified by state regulations through management plans for Yukon River Chinook, summer chum, fall chum, and coho salmon. Accurate daily salmon abundance estimates help managers regulate fishing inseason to meet harvest and escapement objectives, and are used postseason to determine whether treaty obligations were met and to judge effects of management actions.

Prior to 1993, ADF&G used dual-beam sonar equipment that operated at 420 kHz. For the 1993 season, ADF&G changed the existing sonar equipment to operate at a frequency of 120 kHz to allow greater ensonification range by reducing signal loss, and helped increased fish detection at longer ranges (Fleischman et al. 1995). The newly configured equipment's performance was verified using standard acoustic targets in the field.

Until 1995, ADF&G attempted to identify direction of travel of detected targets by aiming transducers at an upstream or downstream oblique angle relative to fish travel. This technique was discontinued in 1995 in favor of aiming transducers perpendicular to fish travel to maximize fish detection (Maxwell et al.1997). Because of this change and subsequent changes in counting procedures, data collected from 1995 to 2014 are not directly comparable to previous years. In 2001, the equipment was changed from dual-beam to the current split-beam sonar system configured to operate at 120 kHz (Pfisterer 2002). Reference to the use of dual-beam sonar at the Pilot Station sonar project can be found in *Yukon River project report, 2000* (Rich 2001). The split-beam technology has the ability to estimate the 3-dimensional position of a target in space, which allows testing of assumptions about direction of travel and vertical distribution of fish moving through the acoustic beam (Burwen et al. 1995).

A series of gillnets using different mesh sizes are drifted through the acoustic sampling areas to apportion the passage estimates to species. In 2004, the selectivity model used in species apportionment was refined through biometric review and analysis of historical catch data from the project's test fishery. The model providing the best overall fit to the data was a Pearson model with a tangle parameter (Bromaghin 2004). Species proportions and passage estimates reported in this document were generated with this apportionment model, and are comparable with estimates from 1995 to 2004, because estimates from these years have been regenerated using the most current model.

Early in the 2005 season, the Yukon River experienced high water levels and erosion causing the formation of a cut bank and steepening the bottom profile on the left bank. The altered bottom profile allowed fish to swim under the beam and increased nearshore fish distribution on the left bank. On June 19, 2005, a multi-beam dual-frequency identification sonar (DIDSON[1]) was deployed in this area to verify nearshore fish detection (Belcher et al. 2002). The wider beam angle, video-like images, and software algorithms that can remove bottom structure from the image allowed the DIDSON system to detect fish passage within 20 m despite high water levels and problematic erosion, and it was operated for the remainder of the season, supplanting split-beam counts in this section of nearshore region. From 2005 until 2014, the project used a combination of fixed-location split-beam sonar and DIDSON, operating side-by-side, to estimate daily upstream passage of fish. The DIDSON sampled the first 20 m of the left bank nearshore stratum and the remainder of the range was sampled by the split-beam.

During the 2008 season, ADF&G implemented a feasibility study to validate a complete switch from paper charts to electronic echograms to count fish traces (Carl Pfisterer, Commercial Fisheries Biologist, ADF&G, Fairbanks; personal communication). The electronic charts were

---

[1] All product names used in this report are included for scientific completeness but do not constitute a product endorsement.

found to provide a number of advantages that include increased number of threshold levels, better consistency (no ribbons that fade), less downtime related to paper jams, and the ability to easily determine direction of travel. In 2009, electronic echograms replaced paper charts to count fish traces (Lozori and McIntosh 2013).

Many sonar projects operate 24 hours per day including the Sheenjek River and Eagle sonars (Dunbar 2013; Crane and Dunbar 2011), as did the Pilot Station sonar project occasionally during developmental years in 1984 and 1985 (Mesiar et al. 1986). Funding reductions during the 1986 season necessitated staffing reductions, and a systematic sampling schedule of three 3-hour sonar periods per day was adopted (Mesiar and LaFlamme 1991). The presence of diel migration patterns would have invalidated this type of sample design, however, sonar feasibility studies in the lower Kuskokwim and Yukon rivers during 1980–1983[2] found no evidence of such patterns. Variance estimates for total fish passage were first developed by Brannian (1986) and for passage by species by Fleischman et al. (1992). Parametric and non-parametric confidence intervals were developed in 1993 (Fleischman et al. 1995).

GOALS AND OBJECTIVES

The primary goal of this project is to estimate daily fish passage, by species, during upstream migration past the sonar site.

The primary project objective was as follows:

1. Provide managers with timely estimates, and associated confidence intervals, of daily and seasonal passage of adult Chinook, chum, and coho salmon.

The secondary project objectives were as follows:

1. Collect biological data from all fish captured in the test fishery, including species, sex, length, and scales, as appropriate.
2. Collect Chinook and chum salmon tissue samples for separate stock identification projects.
3. Collect water temperature data representative of the ensonified areas of the river.

STUDY SITE

Locations in this report are referenced by the proximate bank of the Yukon River, relative to a downstream perspective. At the sonar site the left bank is south of the right bank. Both the village of Pilot Station and the ADF&G sonar camp are located on the right bank.

The Yukon River, at the sonar site, is approximately 1,000 m wide between the left and right bank transducers (Figure 3). The left bank substrate, composed of silt and fine sand, drops off gradually at a vertical angle of approximately 2° to 4°. The right bank has a stable, rocky bottom that drops off uniformly to the thalweg at a vertical angle of approximately 10° (Figure 4). The thalweg is approximately 25 m deep and is located approximately 200 m offshore of the right bank. River height, as observed from 2001 to 2014 at the United States Geological Survey (USGS) gaging station located downstream of the project, has ranged from a maximum of 28.9 ft to a minimum of 13.6 ft from June 1 through September 7 (Figure 5).

---

[2] Nickerson, R. B., and D. Gaudet. Sonar feasibility studies in the Lower Kuskokwim and Yukon Rivers, 1980-1983. Alaska Department of Fish and Game, Division of Commercial Fisheries, Anchorage, unpublished data.

METHODS

Daily upstream migration of targeted fish species are estimated by multiplying the daily sonar passage of all species with the daily proportion of each targeted fish species estimated from the drift gillnet test fishery conducted in the same area as the sonar (Figure 6). Test fishery and sonar sampling were stratified both temporally and physically. The temporal stratification occurs through multiple test fishing and sonar periods per day (Table 1). The physical stratification for test fishery sampling is accomplished with different fishing zones, and for sonar sampling by dividing the right bank into 2 strata (S1 and S2), and dividing the left bank into 3 strata (S3, S4, and S5) (Figure 7). For computational convenience, each stratum was divided into 5 equal-width sectors and each sector was numbered sequentially 1 through 5. For example, if a stratum range was 50 m it would be divided into 5 sectors, each 10 m wide, and the sector closest to shore would be Sector 1.

HYDROACOUSTIC DATA ACQUISITION

Equipment

Left bank sonar equipment included the following:

1. A Hydroacoustic Technology Inc. (HTI) Model 244 echosounder configured to transmit and receive at 120 kHz, controlled via Digital Echo Processing (DEP) software installed on a laptop PC,
2. An HTI 120 kHz split-beam transducer with a 3° x 10° nominal beam width,
3. A 250 ft (76.2) HTI split-beam transducer cable connecting the sounder to the transducer,
4. A DIDSON-LR (Long Range) unit (14° x 29° nominal beam dimension), configured to transmit and receive at 1.2 MHz, and controlled via software installed on a laptop PC, and
5. A 500 ft DIDSON underwater cable connecting the DIDSON to the "topside breakout box" and laptop PC.

Right bank sonar equipment included the following:

1. An HTI Model 244 echosounder configured to operate at 120 kHz, controlled via DEP software installed on a laptop PC,
2. An HTI split-beam 120 kHz transducer with a 6° x 10° nominal beam width, and
3. Three 250 ft (228.6 m combined length) HTI split-beam cables connecting the sounder to the transducer.

The HTI Model 244 echosounders are ideal for use at the project due to their configurability and power. The echosounders are set to transmit and receive at 120 kHz, which is necessary to achieve the sampling ranges. The beam heights for each split-beam transducer were chosen to fit the water column between the bottom and surface with minimal interference, and the 10° width provides adequate field of view. The lengths of cable are necessary for flexibility in placement of the transducers. The DIDSON is ideal for use on the left bank because it is much more robust to bottom and surface interference, so beam width is not an issue. The DIDSON is configured to transmit and receive at 1.2 MHz for the best resolution. Each HTI system configuration of sounder, transducer, and cable was calibrated by the manufacturer prior to the field season. Transducers were mounted on metal tripods and remotely aimed with HTI model 662H dual-axis rotators (Figure 8), which allow for precision in aiming especially at range with the split-beam sonar. Rotator movements were controlled with HTI model 660-2 rotator controllers with position feedback to the nearest 0.1°. Gasoline generators (3000 W) supplied 120 VAC power.

After echogram files were recorded, Echotastic software was used to mark fish traces. Echograms and associated data were stored on a portable hard drive and transferred to an external redundant array of independent disks (RAID) storage system.

Equipment Settings and Thresholds

The split-beam echosounders used a 40 log*R* time-varied gain (TVG) and 0.4 ms transmit pulse duration during all sampling activities. The receiver bandwidth was automatically determined by the equipment based on the transmit pulse duration. On the left bank, the S3 pulse repetition rate (ping rate) was set to 5 pings per second (pps), S4 was set at 3 pps and S5 was set at 1.2 pps. The ping rate for S1 was set at 5 pps and S2 was set at 3 pps (Table 2). The DIDSON operated at an average rate of 8 frames per second. In high-frequency mode (1.2 MHz), the start range was 0.83 m and the end range was 20.84 m (Table 3).

The digital sampling used by both the split-beam and DIDSON eliminates the use of thresholds during raw data collection. However, thresholds were applied to the electronic echogram files when viewed in Echotastic in order to reduce background noise and improve detection of fish traces (Table 4).

Aiming

Transducers were deployed on both the left and right banks in an area where the river is approximately 1,000 m wide. The transducers were always positioned and aimed to maximize fish detection. The transducer was located in the area with the best bottom profile and the beam was oriented approximately perpendicular to the current so that migrating fish would present the largest possible reflective surface. Because many fish travel close to the substrate, the maximum response angle of the beam was oriented slightly above the river bottom through as much of the range as possible. The right bank transducer was positioned as close to shore as possible depending on water level, and aim adjusted to between S1 (0–40 m) and S2 (40–150 m). The left bank split-beam transducer was positioned as close to shore as possible (depending on water level), and utilized 3 distinct aims to sample S3 (0–50 m), S4 (50–150 m), and S5 (150–300 m). The DIDSON unit was normally deployed within 2 m of the split-beam transducer and ensonified the first 20 m of S3 (Figure 7). The DIDSON’s wider beam angle is ideal for the less linear nature of the eroded left bank nearshore stratum, enabling it to detect fish targets throughout more of the water column than the narrower split-beam. When aiming the split-beam for S3, the aim is optimized for the 20–50 m portion of the stratum, which is not ensonified by the DIDSON. In this way, the sonar systems are used in concert to maximize detection for the entire nearshore stratum on left bank. The counts from the 2 systems cannot directly be compared for the 0–20 m area, because the aiming strategy optimizes fish detection for the DIDSON, but not the split-beam, within this range. Additional aiming and sonar site selection protocols for fish counting using side-looking sonar systems can be found in Faulkner and Maxwell (2009).

Fluctuating water levels required repositioning of the transducers, and subsequent re-aiming of the beams. To establish an optimal aim, the transducer was panned horizontally upstream and downstream approximately 15° off perpendicular in 2° increments. At each increment, the vertical tilt was adjusted to obtain the best possible bottom picture using an electronic echogram to confirm that the sonar beam was oriented slightly above the river bottom. The left bank transducers were re-aimed more often to compensate for the dynamic bottom conditions and continual changes associated with that bank. Once an optimal aim was obtained, the rotator settings were documented and the auto rotator settings changed for the new optimal aim.

Sampling Procedures

Acoustic sampling was conducted simultaneously on both banks from 0530–0830, 1330–1630, and 2130–0030 hours, alternating sequentially between strata every 30 minutes (Table 1).

Operators marked fish traces for both the split-beam and the DIDSON system on electronic echograms using Echotastic software developed by ADF&G (Figure 9). All personnel were trained to distinguish between fish tracings and nontarget echoes. Echo traces were counted as a single fish if at least 2 pings in the cluster passed the threshold level and the targets did not resemble inert downstream objects. Valid downstream fish targets were marked along with upstream when computing the total estimate of fish passage for consistency with historical methods. Individuals within groups of fish were distinguishable when the apparent direction of movement of 1 fish trace differed from that of an adjacent trace.

Echograms were reviewed daily by either the project leader or crew leader to monitor the accuracy of the marked fish tracings and reduce individual biases. Each echogram was checked for indications of signal loss and changes in bottom reverberation markings, which could indicate either movement of the transducer or a change in bottom profile. The data was checked daily for data entry or marking errors, then processed in statistical software (SAS) using routines developed by Toshihide Hamazaki, ADF&G Commercial Fisheries Biometrician, Anchorage.

SYSTEM ANALYSES

Performance of the split-beam hydroacoustic system was monitored following many of the procedures first established in 1995 (Maxwell et al. 1997). Monitoring of the DIDSON included daily checks of sonar settings prior to each sampling period, routine checks of water height near the pod, checking aim settings, as well as monthly cleaning of the transducer lens. System analyses included equipment performance checks, bottom profiles using down-looking sonar, and hydrologic measurements.

Bottom Profiles

Bottom profiles were recorded along both banks using a Lowrance LCX15MT recording fathometer with GPS capabilities to locate deployment sites with suitable linear bottom profiles. All bottom profiles were recorded and stored electronically. Inseason, the fathometer was used regularly to monitor changing bottom conditions and to watch for the formation of sandbars capable of re-routing fish to unensonified areas.

Hydrological Measurements

Water levels were sourced from the real-time USGS gaging station located approximately 500 m downstream of Pilot Station and used inseason. Electronic temperature data loggers were deployed to record water temperature on the right bank on June 3 and on the left bank on June 5.

Both loggers remained submerged until September 7. The electronic temperature data loggers were programed to record the water temperature once every hour at the top of the hour. Daily temperature was calculated as the mean of all recorded temperatures for the day.

SPECIES APPORTIONMENT

To estimate species composition of the sonar estimates, gillnets were drifted through 3 zones (right bank, left bank nearshore, and left bank offshore) corresponding to sonar sampling strata (Figure 7). The results of the right bank drift (test fishery Zone 1) were applied to the right bank sonar Strata 1 and 2. The results of the left bank nearshore drift (test fishery Zone 2) were applied only to the sonar estimates in the first stratum on the left bank (S3). The left bank offshore drift (test fishery Zone 3) were applied to the remainder of the left bank sonar estimates (S4 and S5).

A total of 8 different mesh sizes were fished throughout the season to effectively capture all size classes of fish present and detectable by the hydroacoustic equipment (Table 5). All nets were 25 fathoms (45.7 m) long and approximately 8 m deep. All nets were constructed of shade 11, double knot multifilament nylon twine and hung “even” at a 2:1 ratio of web to corkline.

Test fishing began as soon as practical and continued through the last day of sonar operation. Test fishing was conducted twice daily between sonar periods, from 0900–1200 and 1700–2000 hours, except on days when commercial gillnet fishing was scheduled (Table 1). On days of commercial gillnet fishing, only 1 test fish period was conducted during a time to not interfere or overlap with the scheduled commercial period or a sonar operation period. During each normal sampling period, 4 different mesh sizes were drifted within each of 3 zones for a total of 24 drifts per day, except when only 1 test fishing period was conducted in which all 6 mesh sizes were fished (Table 6). The order of drifts were 1) left bank nearshore zone, 2) right bank zone, and 3) left bank offshore zone, with a minimum of 20 minutes between drifts in the same zone. Each mesh size was fished in all 3 zones before switching to the next mesh size. The shoreward end of the left bank nearshore drift was held approximately 5–10 m from the sonar transducers. The left bank offshore drift was approximately 65 m offshore of the transducers so as not to overlap with the nearshore drift. Drifts were approximately 8 minutes in duration, but were shortened as necessary to avoid snags or to limit catches during times of high fish passage.

Captured fish were identified to species and measured to the nearest 1 mm length. Salmon species were measured from mid eye to fork of tail (METF); non-salmon species were measured from tip of snout to fork of tail (FL). Non-salmon species captured and identified included cisco (*Coregonus* spp), humpback whitefish (*C. pidschian*), broad whitefish (*C. nasus*), sheefish (*Stenodus leucichthys*), burbot (*Lota lota*), longnose sucker (*Catostomus catostomus*), Dolly Varden (*Salvelinus malma*), and northern pike (*Esox lucius*). Sex was recorded only for salmon species and was determined by examination of external features. For Chinook salmon that were retained, sex was determined by internal examination of reproductive organs. Fish species, length, and sex were recorded onto field data sheets. Each drift record included the date, sampling period, zone, drift start and end times, mesh size, length of net, and captain’s initials. Handling mortalities among the captured fish were distributed to the local community and fish dispersal was documented daily.

A minimum of 3 scale samples were collected from Chinook salmon and mounted on scale cards, and fish and card numbers were recorded on the test fishing data sheets. Data were transferred from data sheets into a Microsoft Access database. Age, sex, and length (ASL) data are processed, analyzed, and reported annually by ADF&G staff based in Anchorage (e.g., Eaton 2014).

Individual genetic tissue samples from Chinook and chum salmon were also collected, and placed in vials, for several stock identification projects, in conjunction with the test fishing portion of the project. ASL data were cross-referenced with each individual tissue sample. The ADF&G Gene Conservation Laboratory (e.g., DeCovich and Howard 2011) and the U.S. Fish and Wildlife Service (USFWS) Conservation Genetics Laboratory (e.g., Flannery and Wenburg 2015) independently processed and analyzed these tissue samples.

Chinook salmon were classified as either large (>655 mm METF) or small (≤655 mm METF), and small Chinook salmon served as a proxy for 'jacks'. Although there is some temporal overlap between the summer and fall runs of chum salmon, for the purposes of estimating passage, all chum salmon encountered through July 18 were designated as summer chum salmon and after July 18 were designated as fall chum salmon.

ANALYTICAL METHODS

Daily estimates were produced from a multi-component process involving the following:

1. Hydroacoustic estimates of all fish targets passing the site, and species composition derived from test fishing results applied to the undifferentiated hydroacoustic estimates.
2. CPUE estimates used as a separate index by the managers were calculated on a subset of the test fishing data.

Sparse and Missing Data

When sufficient gillnet samples were not available for a given day and zone, the data were pooled with data from 1 or more adjacent days by assigning the same report unit (*u*). Sufficient gillnet samples were not available during commercial gillnet fishing periods; test fishing was not conducted during these times, and during times of low fish passage, catches were too sparse to accurately estimate species proportions and associated error bounds.

CPUE estimates were calculated on a daily basis irrespective of catch size. In contrast, species passage estimates were first calculated based on report units (encompassing 1 or more full days of sampling within a zone), and then apportioned into daily estimates. For any test fishery variable (*x*) the report unit (*u*) encompasses days (*d*), test fishery periods (*p*), and zones (*z*) such that:

$$x_u = \sum_{d,p,z}^{u} x_{dpz} \ . \tag{1}$$

The report unit was also appended to the corresponding days and zones of sonar passage estimates. In effect, any unique combination of day and zone having sufficient test fishery catch was assigned a unique report unit (*u*), and combinations that did not have sufficient catch for accurate apportionment were initially pooled by assigning the same report unit across adjacent days within the same zone. When pooling resulted in sufficient test fishery catch, estimates by species could then be calculated, and those species estimates were in turn re-apportioned back into daily estimates based on sonar passage estimates during that time.

Catch Per Unit Effort

CPUE estimates used as separate indices by managers, and not for species apportionment, were calculated for each day (*d*) and bank (*b*) using 2 gillnet suites (*g*) of specific size mesh (*m*). Chinook salmon CPUE was calculated on the pooled catch (*c*) and effort (*f*) of the large mesh gillnets (7.5 in and 8.5 in); chum and coho salmon CPUE was calculated on the pooled catch and effort of the small mesh gillnets (5.25 in, 5.75 in and 6.5 in).

The duration of the test fishery drift (*j*) in minutes (*t*) was calculated as:

$$t_j = (SIj - FOj) + \frac{(FOj - SOj)}{2} + \frac{(FIj - SIj)}{2}. \tag{2}$$

Where:

SO = the time the net is initially set out,

FO = the time the net is fully set out,

SI = the time the net starts back in,

FI = the time the net is fully retrieved in.

The total fishing effort (in fathom-hours) for each day, bank, and gillnet suite was calculated as:

$$f_{dbg} = \sum_g \frac{25 \cdot t_{dbg}}{60}, \tag{3}$$

because all nets were 25 fathoms (45.7 m) in length. CPUE estimates (in catch per fathom-hour) for each species (*i*) were made daily for the right and left banks as:

$$CPUE_{dbi} = \frac{\sum_g c_{dbig}}{f_{dbg}}. \tag{4}$$

Species Composition

To estimate species proportions, first the total effort (*f*), in fathom-hours, of drift (*j*) with mesh size (*m*) during report unit (*u*) was calculated by multiplying the drift time (*t*), calculated as in Equation 3, for each mesh, drift, and reporting unit by 25 fathoms and dividing by 60 minutes per hour:

$$f_{umj} = \frac{25 \cdot t_{umj}}{60}. \tag{5}$$

Total effort for each mesh size fished was then summed over each report unit:

$$f_{um} = \sum_j f_{umj}, \tag{6}$$

and the catch of species (*i*) of length (*l*) in each report unit (*u*) was summed across all mesh sizes,

$$c_{uil} = \sum_m c_{uilm}. \tag{7}$$

For the catch of each species (i) of length (l), the associated effort was adjusted by applying a length-based selectivity parameter (S) (Appendix A1) derived from the Pearson *T* net selectivity model (Bromaghin 2004):

$$f'_{uil} = \sum_m \left(S_{ilm} \cdot f_{um}\right). \tag{8}$$

The CPUE of the catch of each species (i) of length (l) was calculated as:

$$CPUE'_{uil} = \frac{c_{uil}}{f'_{uil}}. \tag{9}$$

The proportion (p) of species (i) during report unit (u) was estimated as the ratio of the CPUE for species (i) to the CPUE of all species combined:

$$\hat{p}_{ui} = \frac{\sum_l CPUE'_{uil}}{\sum_{i,l} CPUE'_{uil}}. \tag{10}$$

The variance was estimated from the squared differences between the proportion for each test fishery period (x) for each day (d) within the report unit ($\hat{p}_{udxi}$) and the proportion for the report unit as a whole ($\hat{p}_{ui}$):

$$\hat{V}ar(\hat{p}_{ui}) = \frac{\sum\left(\hat{p}_{ui} - \hat{p}_{udxi}\right)^2}{n_u \cdot \left(n_u - 1\right)}, \tag{11}$$

where n_u is the number of test fishery sampling periods within the report unit.

Sonar Passage Estimates

Total fish passage was estimated separately for each of the same 3 test fishery zones used in the species apportionment. Test fishery Zone 1 consisted of the entire counting range on the right bank, corresponding to S1 and S2 (approximately 0–150 m). Test fishery Zone 2 consisted of the counting range corresponding to S3 (approximately 0–50 m on the left bank). Test fishery Zone 3 consisted of the counting range corresponding to S4 and S5 (approximately 50–150 m and 150–300 m on the left bank, respectively) (Figure 7).

Within S3, passage was simultaneously estimated in Sectors 1 and 2 (representing approximately the first 20 m) using both the DIDSON and the HTI sonar. Although the DIDSON data were primarily used to generate estimates in those 2 sectors, the HTI system data were also tallied because operating it in Sectors 3, 4, and 5 also entailed operating in Sectors 1 and 2. Because the ranges of the 2 systems did not always precisely overlap, a passage rate for the DIDSON (targets per meter per hour) was first calculated then expanded by the sector width and count time of the corresponding HTI sample to provide consistent width and count time for Sectors 1–5. This was done primarily as a matter of calculation convenience.

First, for Sectors 1 and 2 of Stratum 3, the sector widths (*w*), in meters, were calculated for all samples (*q*) on each day (*d*) and period (*p*) for both the DIDSON and HTI data. The DIDSON unit ensonifies over a single continuous range whereas the HTI subdivides this range into equal width sectors (*k*) 1 and 2 of stratum (*s*) 3. Sector widths for both systems are based on the start and end points of the range in meters referenced from the face of the transducer, such that:

$$w_{dpskq} = End_{dpskq} - Start_{dpskq}. \tag{12}$$

The mean width of sectors (*k*) 1 and 2 of the HTI samples were calculated as:

$$w_{HTI} = \frac{\sum_{s=3} \sum_{q} w_{dpksq}}{n}, \tag{13}$$

and the width of the DIDSON as:

$$w_{DID} = \frac{\sum_{q} w_{dpq}}{n}, \tag{14}$$

where *n* is the number of samples. The total hours (*h*) sampled with the HTI system:

$$h_{HTI} = \sum_{q} h_{dpkq}, \tag{15}$$

and the DIDSON as:

$$h_{DID} = \sum_{q} h_{dpq}, \tag{16}$$

were summed, as were the total upstream counts (*y*):

$$y_{HTI} = \sum_{q} y_{dpkq} \text{ and} \tag{17}$$

$$y_{DID} = \sum_{q} y_{dpq}. \tag{18}$$

Passage rates (*r*) in fish per hour per meter were then calculated for both the DIDSON and the HTI systems:

$$r_{DID} = \frac{y_{DID}}{w_{DID} \cdot h_{DID}} \text{ and} \tag{19}$$

$$r_{HTI} = \frac{y_{HTI}}{w_{HTI} \cdot h_{HTI}}. \tag{20}$$

Due to better detection capabilities at close range, and the aiming methods described above, it was typical that the DIDSON passage rate would exceed the HTI passage rate in both Sectors 1 and 2. In this case, a passage estimate was generated for the time sampled by expanding the DIDSON using the HTI sector width and hours:

$$y_{dpk} = r_{DID} \cdot w_{HTI} \cdot h_{HTI}. \tag{21}$$

However, in the event of a system failure or data loss using the DIDSON, the HTI estimate for those 2 sectors would be retained and used in subsequent calculations. In this case, the estimates for this time period would be considered conservative.

Total upstream fish passage (*y*) on day (*d*), during sonar period (*p*), in zone (*z*), and stratum (*s*) was then calculated by summing net upstream targets over all sectors (*k*) and samples (*q*):

$$y_{dpzs} = \sum_{q} \sum_{k} y_{dpzsqk} \ . \tag{22}$$

The duration, in hours (*h*), of the time sampled was calculated as:

$$h_{dpzs} = \sum_{q} \sum_{k} h_{dpzsqk} \ . \tag{23}$$

The hourly passage rate (*r*) for day (*d*), sonar period (*p*), and zone (*z*) was computed as a ratio of the sum of the estimated upstream passage in stratum (*s*) to the duration (hours) of the sample:

$$r_{dpz} = \frac{\sum_{s} y_{dpzs}}{\sum_{s} h_{dpzs}} \ . \tag{24}$$

Total passage of fish in a report unit ($\hat{y}_u$) was estimated as the product of the average hourly passage rate and the total hours encompassed by the report unit:

$$\hat{y}_u = (d_2 - d_1 + 1)_u \cdot 24 \cdot \left(\frac{\sum_{d,p,z \in u} r_{dpz}}{n_u} \right), \tag{25}$$

where d_1 is the first day, d_2 is the last day, and n_u is the number of sonar sampling periods in report unit (*u*).

Sonar sampling periods, each 3 hours in duration, were spaced at regular (systematic) intervals of 8 hours. Treating the systematically sampled sonar counts as a simple random sample could yield an over-estimate of the variance of the total because sonar counts are highly auto correlated (Wolter 1985). To accommodate these data characteristics, a variance estimator based on the squared differences of successive observations, recommended by Brannian (1986) and modified from Wolter (1985), was employed:

$$\hat{V}ar(\hat{y}_u) = \left[(d_2 - d_1 + 1)_u \cdot 24\right]^2 \cdot \left[1 - \frac{h_u}{(d_2 - d_1 + 1)_u \cdot 24}\right] \cdot \frac{\sum_{p=2}^{n_u} (r_{up} - r_{u,p-1})^2}{2n_u(n_u - 1)} , \tag{26}$$

where r_{up} is the passage rate in reporting unit (u) for period (p), and

$$1 - \frac{h_u}{(d_2 - d_1 + 1)_u \cdot 24}, \tag{27}$$

is the finite population correction factor.

Fish Passage by Species

The passage of species (i) was estimated for each report unit (u) as the product of the species proportion (p) (Equation 11) and sonar passage (y) (Equation 26):

$$\hat{y}_{ui} = \hat{y}_u \cdot \hat{p}_{ui}. \tag{28}$$

Except for the timing of sonar and gillnet sampling periods, sonar-derived estimates of total fish passage were independent of gillnet-derived estimates of species proportions. Therefore, the variance of their product (daily species passage estimates y_{idz}) was estimated as the variance of the product of 2 independent random variables (Goodman 1960):

$$\hat{V}ar\left(\hat{y}_{ui}\right) = \hat{y}_u^2 \cdot \hat{V}ar\left(\hat{p}_{ui}\right) + \hat{p}_{ui}^2 \cdot \hat{V}ar\left(\hat{y}_u\right) - \hat{V}ar\left(\hat{y}_u\right) \cdot \hat{V}ar\left(\hat{p}_{ui}\right). \tag{29}$$

Passage estimates were assumed independent between reporting units, and therefore the variance of their sum was estimated by the sum of their variances:

$$\hat{V}ar(\hat{y}_i) = \sum_u \hat{V}ar(\hat{y}_{ui}). \tag{30}$$

Because most users of this data were interested in daily passage by species rather than passage for reporting units, the daily species passage by zone was estimated by calculating the proportion of the hourly passage rate for the day and zone to the hourly passage rate for the report unit:

$$\hat{p}_{dz} = \frac{r_{udz}}{r_u}, \tag{31}$$

and then applying the passage proportion (p) to the report unit estimate (y):

$$\hat{y}_{dzi} = \hat{y}_{ui} \cdot \hat{p}_{dz}. \tag{32}$$

Total daily passage by species was estimated by summing over all zones:

$$\hat{y}_{di} = \sum_z \hat{y}_{dzi}. \tag{33}$$

At this stage, there were 2 potential ways of calculating total season passage: summing the estimates across days or reporting units. Each can produce slightly different totals due to small rounding errors. To prevent confusion, passage estimates were summed over all zones and days to obtain a seasonal estimate for species (y_i), because this is how the estimates are reported:

$$\hat{y}_i = \sum_d \sum_z \hat{y}_{dzi}. \tag{34}$$

Assuming normally distributed errors, 90% confidence intervals were calculated as:

$$\hat{y}_i \pm 1.645\sqrt{\hat{V}ar(\hat{y}_i)}\ . \tag{35}$$

SAS program code (Toshihide Hamazaki, Commercial Fisheries Biometrician, ADF&G, Anchorage; personal communication) was used to calculate CPUE, passage estimates, and estimates of variance.

RESULTS

The Pilot Station sonar project crew arrived at the sonar site on May 30 and began camp setup. Test fishing began on the evening of June 1. The right bank split-beam sonar was deployed and operational for Period 3 sonar on June 3. The left bank split-beam sonar was deployed and operational for Period 3 sonar on June 5. The DIDSON was deployed and operational for Period 3 sonar on June 5. The project was operational beginning with Period 3 sonar on June 5 and continued operations through September 7. Passage estimates were transmitted to fishery managers in Emmonak daily.

ENVIRONMENTAL AND HYDROLOGICAL CONDITIONS

Ice break-up on the Yukon River at Pilot Station occurred on May 3, which was unusually early and allowed camp to be set up on schedule (Table 7). The water level during the 2014 season was uncharacteristically low during the first 2 weeks of June near Pilot Station, but rose during mid-June and remained above the 2001–2013 mean throughout remainder of the season (Figure 5). Mean daily water temperatures on the left bank ranged from 11.3–17.7°C and 10.4–18.4°C on the right bank (Figure 10).

TEST FISHING

Drift gillnetting resulted in the capture of 10,413 fish: 515 Chinook salmon, 4,000 summer chum salmon, 1,870 fall chum salmon, 1,196 coho salmon, and 2,832 fish of other species. Of the captured fish, 3,096 (29.7%) were retained as mortalities and delivered to local users to help meet subsistence needs within the nearby community of Pilot Station (Table 8). Scale samples were collected from 514 of the Chinook salmon captured in the test fishery. A tissue sample for genetic stock identification was taken from 506 Chinook salmon and 5,835 chum salmon. Daily CPUE data are reported in Appendices B1 and B2.

HYDROACOUSTIC ESTIMATES

An estimated 4,438,214 fish passed through the sonar sampling areas between June 3 and September 7, including 865,883 (19.5%) along the right bank, 2,259,301 (50.9%) along the left bank nearshore, and 1,313,030 (29.6%) along the left bank offshore (Table 9). Total fish passage estimates, by zone and with their associated errors, were calculated daily (Appendix C1).

On the left bank, over 90% of the fish passage occurred within 100 m of the transducer in the summer season. During the fall season, distribution was slightly more dispersed because approximately 90% of the fish passage occurred within 120 m. On the right bank, approximately 90% of the fish passage occurred within 70 m during both summer and fall seasons (Figures 11–12).

SPECIES ESTIMATES

Fish passage estimates by species were generated daily and then reported to fishery managers (Appendix D1). The cumulative passage estimates, with 90% confidence interval, for Chinook salmon comprises 103,613 ± 14,963 large Chinook salmon (>655 mm METF) and 34,372 ± 7,931 small Chinook salmon (≤655 mm METF). The cumulative passage estimates for chum salmon comprises 1,924,425 ± 100,258 summer chum salmon and 650,808 ± 63,620 fall chum salmon. The cumulative passage estimate for coho salmon was 247,047 ± 27,257 fish, for pink salmon was 513,599 ± 60,113 fish, and for other species (whitefish, cisco, sheefish, burbot, longnose sucker, Dolly Varden, sockeye salmon, and northern pike) was 964,350 ± 83,573 fish (Table 9).

Within the 0–20 m region of the left bank nearshore, where the DIDSON was the primary sonar used for generating passage estimates, an additional 10,461 Chinook, 156,228 summer chum, 40,878 fall chum, and 17,793 coho salmon were contributed by the DIDSON relative to the split-beam estimates. Daily DIDSON estimates of fish passing through this region of the left bank and the associated proportion are also referred to as the DIDSON contribution (Appendices E1 and E2).

The initial pulse of Chinook and summer chum salmon began approximately June 8 (Figure 13). Compared to historical mean run timing for 2004–2013, the midpoint of the Chinook salmon run occurred 7 days early (June 19), and 5 days early (June 23) for summer chum salmon (Figure 14; Appendix F1).

There were 5 pulses of fall chum salmon observed after July 18 and the first pulse occurred approximately July 23 (Figure 15). Inseason mixed stock analysis (MSA) from the Pilot Station sonar project test fishery was used to generate stock composition estimates of pulses, which were distributed inseason to assist in management decisions. Of the 5 pulses, the fall chum salmon composition ranged from 75.1% to 95.7% and the summer chum salmon composition ranged from 4.3% to 24.9% (Table 10; B.G. Flannery, USFWS Conservation Genetics Laboratory Anchorage, personal communication). The midpoint for the fall chum salmon run fell on August 16, which was 6 days late when compared to 2004–2013 mean cumulative run timing (Figure 16; Appendix F1).

The first pulse of coho salmon arrived approximately August 7. There were several additional pulses of coho salmon through September 7 (Figure 15). As in most years, the project ends before the coho salmon run is complete; therefore, estimates are considered conservative. Coho salmon continued to enter the Yukon River after September 7 and were monitored at the Lower Yukon test fishery (LYTF) near Emmonak through September 20, but no additional pulses were observed (Estensen and Borba 2014). The midpoint for the coho salmon run was on August 23, which was 2 days late when compared to 2004–2013 mean cumulative run timing (Figure 16; Appendix F1).

MISSING DATA

During initial startup, between June 3 and June 5, at least 1 bank had partial days of sonar operation. The right bank split-beam sonar began operating during Period 3 on June 3. The left bank split-beam sonar and DIDSON began operating during Period 3 on June 5. Additionally, at the beginning of the summer season, there were 4 days (June 1–June 4) that had insufficient catch in at least 1 zone. The first commercial dip netting period occurred on June 9 in District 2, and that canceled 1 test fishing period for that day. Beginning near the middle of the summer season, 6 commercial gillnet fishing periods occurred in District 2 that canceled 1 of the daily test fishing periods on each of those days. During the fall season, 8 commercial fishing periods occurred in District 2 that canceled 1 of the daily test fishing periods on each of those days. July 31 had insufficient catch in at least 1 zone. In order to estimate variance accurately, days with missing test fishing periods were pooled with adjacent days that had 2 complete test fishing periods, and zones with insufficient catches were pooled with zones with sufficient catches on adjacent days (Table 11).

DISCUSSION

The right bank bottom profiles were similar to prior years with little or no change throughout the season. The left bank profiles remained linear throughout the season, and there were no problems in finding suitable transducer locations. Whereas in previous years there have been problems with silt attenuation or reverberation bands, in 2014 there were no major problems with either. A concern in recent years has been the left bank sandbar downstream of the ensonified area. During periods of low water, this sandbar, which is located in the left bank nearshore test fishery zone, can cause nets to drag the bottom and stall. It is uncertain if the sandbar forces the fish further offshore and causes them to remain farther offshore after they have made their way around the sandbar, but during the 2009 field season, it was speculated that fall chum salmon estimates may have been underestimated because of effects caused by the sandbar (Lozori and McIntosh 2013). The left bank sandbar did not seem to affect fish distribution this season, because the left bank fish distributions were similar to previous years. Investigations should be considered in the future to compare alternative test fishing methods, including using CPUE data from alternate test fishery sites to increase the accuracy of fish passage estimates generated at the Pilot Station sonar project during periods when this sandbar is shallow enough to cause issues with the project's test fishery and fish passage distribution.

The DIDSON contribution is defined as the additional fish count over and above the total split-beam estimate in the same area. Of the total passage by species, the DIDSON accounted for 7.6% of Chinook, 8.1% of summer chum, 6.3% of fall chum, and 7.2% of coho salmon. Overall, the DIDSON contributed to 10.2% of the total passage estimate (Figure 17). This highlights that though the DIDSON complements the sonar sampling plan on the left bank, the nature of the left bank substrate, water level, and fish distribution are all factors in determining the DIDSON's relative contribution to the overall passage estimate in any given season.

Chinook salmon passage estimates at the Pilot Station sonar project for 2014 exceeded the 2013 estimates, and was the eighth highest since 1995. Summer chum salmon passage estimates for 2014 were below the 2013 estimates, but were the sixth highest on record since 1995. Fall chum salmon passage estimates at the Pilot Station sonar project for 2014 were below the 2013 estimates, and were the eighth highest since 1995. Despite the late run timing, the total estimated coho salmon passage at the Pilot Station sonar project was the second highest passage on record since 1995 (Figure 16; Appendix G1).

Although there were very few problems this season, estimating fish passage on the Yukon River continues to present major technical and logistical challenges. The sampling environment is often demanding due to the extremely dynamic nature of the water level, turbidity, bottom substrate, and range dependent signal loss. The hydroacoustic system we employ at the Pilot Station sonar project appears to work well for the purpose of detecting migrating salmon, but successful estimation depends on constant attention to the frequent changes and diligent re-checking of every part of the acoustic and environmental system. In 2014, all project goals were met and passage estimates were given to fisheries managers daily during the season. Information generated at the Pilot Station sonar project was disseminated weekly through multi-agency international teleconferences and data was shared with stakeholders in areas from the Lower Yukon River, all the way to the spawning grounds in Canada.

ACKNOWLEDGEMENTS

The authors would like to thank the following organizations for their support: Association of Village Council Presidents for providing a technician, and U.S. Fish and Wildlife Service for providing a volunteer technician and funding for genetic analysis and transport of samples. This project was also supported by U.S./Canada funds administered by the U.S. Fish and Wildlife Service, Agreement FWS #F12AP00798.

The authors would also like to thank the following people for their hard work and dedication to the project during the 2014 season: crew leader Christine Gleason, and technicians Maureen Chambrone, Matthew Joseph, Donald Kelly (AVCP technician), Joseph Liu, Jason Warta, Kendall Nielsen, and Emily Bryson, as well as Carl Pfisterer (Regional Sonar Coordinator) for his assistance in the field and careful review of this report, and Benjamin Gray (2015 crew leader) for his assistance and careful review of this report.

REFERENCES CITED

Belcher, E. O., W. Hanot, and J. Burch. 2002. Dual-frequency identification sonar. Proceedings of the 2002 International Symposium on underwater technology, held April 16-19, 2002. Tokyo, Japan. Pages 187-192.

Brannian, L. 1986. Development of an approximate variance for sonar counts. 24 December Memorandum to William Arvey, AYK Regional Research Biologist, Alaska Department of Fish and Game, Division of Commercial Fisheries, Anchorage.

Bromaghin, J. F. 2004. An evaluation of candidate net selectivity models for 1990-2003 Yukon River Sonar gill-net catch data. U.S. Fish and Wildlife Service. Alaska Fisheries Technical Report Number 75. Anchorage.

Burwen, D. L., D. E. Bosh, and S. J. Fleischman. 1995. Evaluation of hydroacoustic assessment techniques for Chinook salmon on the Kenai River using split-beam sonar. Alaska Department of Fish and Game, Fishery Data Series No. 95-45, Anchorage.

Crane, A. B., and R. D. Dunbar. 2011. Sonar estimation of Chinook and fall salmon passage in the Yukon River near Eagle, Alaska, 2010. Alaska Department of Fish and Game, Fishery Data Series No. 11-72, Anchorage.

DeCovich, N. A., and K. G. Howard. 2011. Genetic stock identification of Chinook salmon harvest on the Yukon River 2010. Alaska Department of Fish and Game, Fishery Data Series No. 11-65, Anchorage.

Dunbar, R. D. 2013. Sonar estimation of fall chum salmon abundance in the Sheenjek River, 2012. Alaska Department of Fish and Game, Fishery Data Series No. 13-36, Anchorage.

Eaton, S. M. 2014. Salmon age and sex composition and mean lengths for the Yukon River area, 2013. Alaska Department of Fish and Game, Fishery Data Series No. 14-59, Anchorage.

Estensen, J., and B. Borba. 2014. 2014 Yukon River fall season summary. Alaska Department of Fish and Game, Division of Commercial Fisheries, Fairbanks. http://www.adfg.alaska.gov/static/applications/dcfnewsrelease/505439194.pdf (Accessed December 2014).

Faulkner, A. V., and S. L. Maxwell. 2009. An aiming protocol for fish-counting sonars using river bottom profiles from a Dual-frequency identification sonar (DIDSON). Alaska Department of Fish and Game, Fishery Manuscript No. 09-03, Anchorage.

REFERENCES CITED (Continued)

Flannery, B. G., and J. K. Wenburg. 2015. Application of mixed-stock analysis for Yukon River chum salmon. U.S. Fish and Wildlife Service, Fisheries Resource Monitoring Program, Office of Subsistence Management, Annual Report for Study 10-205, Anchorage.

Fleischman, S. J., D. C. Mesiar, and P. A. Skvorc II. 1992. Yukon River sonar escapement estimate 1991. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 3A92-08, Anchorage.

Fleischman, S. J, D. C. Mesiar, and P. A. Skvorc II. 1995. Lower Yukon River sonar project report 1993. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report3A95-33, Anchorage.

Goodman, L. A. 1960. On the exact variance of products. Journal of the American Statistical Association 55:708-713.

Lozori, J. D., and B. C. McIntosh. 2013. Sonar estimation of salmon passage in the Yukon River near Pilot Station, 2009. Alaska Department of Fish and Game, Fishery Data Series No. 13-28, Anchorage.

Maxwell, S. L., D. C. Huttunen, and P. A. Skvorc, II. 1997. Lower Yukon River sonar project report 1995. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 3A97-42, Anchorage.

Mesiar, D. C., D. M. Eggers, and D. M. Gaudet. 1986. Hydroacoustic enumeration of salmon escapement to the Yukon River in 1985. Alaska Department of Fish and Game, Division of Commercial Fisheries, Arctic-Yukon-Kuskokwim Region Yukon River Salmon Escapement Report No. 27, Juneau.

Mesiar, D. C., and T. R. LaFlamme. 1991. Yukon River sonar escapement estimate, 1986. Alaska Division of Fish and Game, Division of Commercial Fisheries, Regional Information Report 3A91-03, Anchorage.

Rich, C. F. 2001. Yukon River project report 2000. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 3A01-13, Anchorage.

Pfisterer, C. P. 2002. Estimation of Yukon River passage in 2001 using hydroacoustic methodologies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 3A02-24, Anchorage.

Wolter, K. M. 1985. Introduction to variance estimation. Springer-Verlag, New York.

Yukon River Panel. 2004. Yukon River Panel reference manual, The Yukon River salmon agreement. Yukon River Panel, Whitehorse, Yukon Territory.

TABLES AND FIGURES

Table 1.–Daily sampling schedule for sonar and test fishing, at the Pilot Station sonar project on the Yukon River, 2014.

	Sonar		
Time	Right bank	Left bank	Test fishing
	Period 1		
0530	S1	S3	
0600	S2	S4	
0630	S1	S5	
0700	S2	S3	
0730	S1	S4	
0800	S2	S5	
0830			
0900			Period 1
0930			
1000			
1030			
1100			
1130			
1200			
1230			
1300	Period 2		
1330	S1	S3	
1400	S2	S4	
1430	S1	S5	
1500	S2	S3	
1530	S1	S4	
1600	S2	S5	
1630			
1700			Period 2
1730			
1800			
1830			
1900			
1930			
2000			
2030			
2100	Period 3		
2130	S1	S3	
2200	S2	S4	
2230	S1	S5	
2300	S2	S3	
2330	S1	S4	
0000	S2	S5	

Note: S1 = Stratum 1, S2 = Stratum 2, S3 = Stratum 3, S4 = Stratum 4, S5 = Stratum 5.

Table 2.–Initial split-beam sonar settings at the Pilot Station sonar project on the Yukon River, 2014.

			Bank	
Component	Setting	Stratum	Left	Right
Transducer	Beam size (h x w)		3º x 10º	6º x 10º
Echosounder	Transmit power (dB)	S1		30.0
		S2		30.0
		S3	27.0	
		S4	30.0	
		S5	30.0	
	Receiver gain (dB)	S1		-14.0
		S2		-14.0
		S3	-12.0	
		S4	-12.0	
		S5	-12.0	
	Source Level (dBµPa @ 1m)	S1		221.2
		S2		221.2
		S3	222.2	
		S4	223.1	
		S5	223.1	
	Through-system gain (dB)		-161.5	-162.5
	Pulse width (ms)		0.4	0.4
	Blanking range (m)		2.0	2.0
	Ping rate (pps)	S1		5.0
		S2		3.0
		S3	5.0	
		S4	3.0	
		S5	1.2	
	Range (m)	S1		40
		S2		150
		S3	50	
		S4	150	
		S5	300	

Table 3.–Technical specifications for the dual-frequency identification sonar (DIDSON), at the Pilot Station sonar project on the Yukon River, 2014.

Identification mode	Operating frequency	1.2 MHz
	Beam width (2-way)	0.5° H by 12 ° V
	Number of beams	48
Range settings	Start range	0.83 m
	Window length	20.01 m
Range bin size		39 mm
Pulse length		46 μs
Frame rate		8 frames/s
Field of View		29°

Table 4.–Range of lower and upper thresholds used in Echotastic, at the Pilot Station sonar project on the Yukon River, 2014.

		Threshold (dB)	
Bank	Stratum	Upper	Lower
Right	S1	-10	-70
	S2	-10	-70
Left	S3	-4	-90
	S4	-10	-70
	S5	-2	-65
	DIDSON	-1	-55

Table 5.–Specifications for drift gillnets used for test fishing, by season, at the Pilot Station sonar project on the Yukon River, 2014.

	Stretch mesh size		Mesh diameter	Meshes deep	Depth
Season	(in)	(mm)	(mm)	(MD)	(m)
Summer	2.75	70	44	131	8.0
(6/01–7/18)	4.00	102	65	90	8.0
	5.25	133	85	69	8.0
	6.50	165	105	55	7.9
	7.50	191	121	48	8.0
	8.50	216	137	43	8.1
Fall	2.75	70	44	131	8.0
(7/19–9/07)	4.00	102	65	90	8.0
	5.00	127	81	72	8.0
	5.75	146	93	63	8.0
	6.50	165	105	55	7.9
	7.50	191	121	48	8.0

Table 6.–Fishing schedule for drift gillnets used for test fishing by season, at the Pilot Station sonar project on the Yukon River, 2014.

	Test fish	Mesh size (in)			
Season	Period	Odd days		Even days	
Summer	1	2.75	5.25	8.50	4.00
(6/01–7/18)		7.50	6.50	7.50	6.50
	2	7.50	6.50	7.50	6.50
		8.50	4.00	2.75	5.25
Fall	1	4.00	5.75	2.75	7.50
(7/19–9/07)		5.00	6.50	5.00	6.50
	2	5.00	6.50	5.00	6.50
		2.75	7.50	4.00	5.75

Table 7.–Yukon River ice breakup dates at Pilot Station, 2001–2014.

Year	Breakup Date
2014	5/03
2013	5/31
2012	5/17
2011	5/17
2010	5/19
2009	5/17
2008	5/19
2007	5/11
2006	5/25
2005	5/11
2004	5/03
2003	5/15
2002	5/18
2001	5/29

Source: National Oceanic and Atmospheric Administration (NOAA).

http://aprfc.arh.noaa.gov/php/brkup/getbrkup.php?riverbasin=Yukon&river=Yukon+River (Accessed October 2, 2014).

Table 8.–Number of fish caught and retained in the Pilot Station sonar project test fishery on the Yukon River, 2014.

Total Catch	Chinook	S. Chum	F. Chum	Sockeye	Coho	Pink	Whitefish	Cisco	Burbot	Sheefish	Others [a]	Total
June	466	2,758	0	7	0	139	74	101	29	85	55	3,714
July	47	1,242	654	7	10	1,153	176	178	5	17	17	3,506
August	2	0	1,172	5	923	63	353	219	16	22	36	2,811
September	0	0	44	1	263	0	22	36	6	2	8	382
Total	515	4,000	1,870	20	1,196	1,355	625	534	56	126	116	10,413

Fish Retained

	Chinook	S. Chum	F. Chum	Sockeye	Coho	Pink	Whitefish	Cisco	Burbot	Sheefish	Others [a]	Total
June	76	1,566	0	6	0	1	15	16	6	34	1	1,721
July	4	321	148	5	0	0	74	12	0	3	0	567
August	0	0	424	1	155	14	156	11	3	1	0	765
September	0	0	11	1	28	0	2	0	1	0	0	43
Total	80	1,887	583	13	183	15	247	39	10	38	1	3,096

Proportion Retained

	Chinook	S. Chum	F. Chum	Sockeye	Coho	Pink	Whitefish	Cisco	Burbot	Sheefish	Others [a]	Total
June	0.163	0.568	0.000	0.857	0.000	0.007	0.203	0.158	0.207	0.400	0.000	0.463
July	0.085	0.258	0.226	0.714	0.000	0.000	0.420	0.067	0.000	0.176	0.000	0.162
August	0.000	0.000	0.362	0.200	0.168	0.222	0.442	0.050	0.188	0.045	0.000	0.272
September	0.000	0.000	0.250	1.000	0.106	0.000	0.091	0.000	0.167	0.000	0.000	0.113
Total	0.155	0.472	0.312	0.650	0.153	0.011	0.395	0.073	0.179	0.302	0.009	0.297

[a] Includes longnose sucker, Dolly Varden, and northern pike.

Table 9.–Cumulative fish passage estimates by zone and species with standard errors (SE) and 90% confidence intervals (CI), at the Pilot Station sonar project on the Yukon River, 2014.

		Left Bank				90% CI	
Species	Right Bank	Nearshore	Offshore	Total passage	SE	Lower	Upper
Large Chinook [a]	11,241	44,028	48,344	103,613	9,096	88,650	118,576
Small Chinook [b]	5,548	16,182	12,642	34,372	4,821	26,441	42,303
Total Chinook	16,789	60,210	60,986	137,985	10,295	121,050	154,920
Summer chum	383,094	846,878	694,453	1,924,425	60,947	1,824,167	2,024,683
Fall chum	50,494	273,574	326,740	650,808	38,675	587,188	714,428
Coho	35,988	75,908	135,151	247,047	16,569	219,790	274,304
Pink	124,421	356,148	33,030	513,599	36,543	453,486	573,712
Other	255,097	646,583	62,670	964,350	50,804	880,777	1,047,923
Total	865,883	2,259,301	1,313,030	4,438,214			

[a] Chinook salmon >655 mm.

[b] Chinook salmon ≤655 mm.

[c] Includes sockeye salmon, cisco, whitefish, sheefish, burbot, longnose sucker, Dolly Varden, and northern pike.

Table 10.–Genetic composition of chum salmon, sampled at the Pilot Station sonar project on the Yukon River, 2014.

	Percentage	
Date	Summer chum	Fall chum
6/01–6/08	99.4	0.6
6/09–6/15	99.1	0.9
6/16–6/22	99.6	0.4
6/23–6/29	98.9	1.1
6/30–7/06	99.1	0.9
7/07–7/13	98.4	1.6
7/14–7/18	68.1	31.9
7/19–7/27	24.9	75.1
7/28–8/06	11.4	88.6
8/07–8/17	4.9	95.1
8/18–8/24	4.3	95.7
8/25–9/07	9.3	90.7

Table 11.–Reporting units of zones pooled for the 2014 season, at the Pilot Station sonar project on the Yukon River.

		Left Bank		
Date	Right Bank (Zone 1)	Nearshore (Zone 2)	Offshore (Zone 3)	Reason for pooling [a]
06/01 06/02 06/03 06/04	1	2	3	IC
06/08 06/09	13	14	15	CO
07/05 07/06	91	92	93	CO
07/07 07/08	94	95	96	CO
07/09 07/10	97	98	99	CO
07/11 07/12	100	101	102	CO
07/13 07/14	103	104	105	CO
07/15 07/16	106	107	108	CO
07/19 07/20	112	113	114	CO
07/26 07/27	133	134	135	CO
07/30 07/31			144	IC
08/02 08/03	150	151	152	CO
08/17 08/18	192	193	194	CO
08/21 08/22	201	202	203	CO
08/23 08/24	204	205	206	CO
08/26 08/27	210	211	212	CO
08/29 08/30	216	217	218	CO

[a] CO denotes that a commercial opening prevented test fishing, and therefore pooling across days enables the variance estimation of species proportions. IC denotes that zones were pooled when there was insufficient catch in the test fishery for variance estimation.

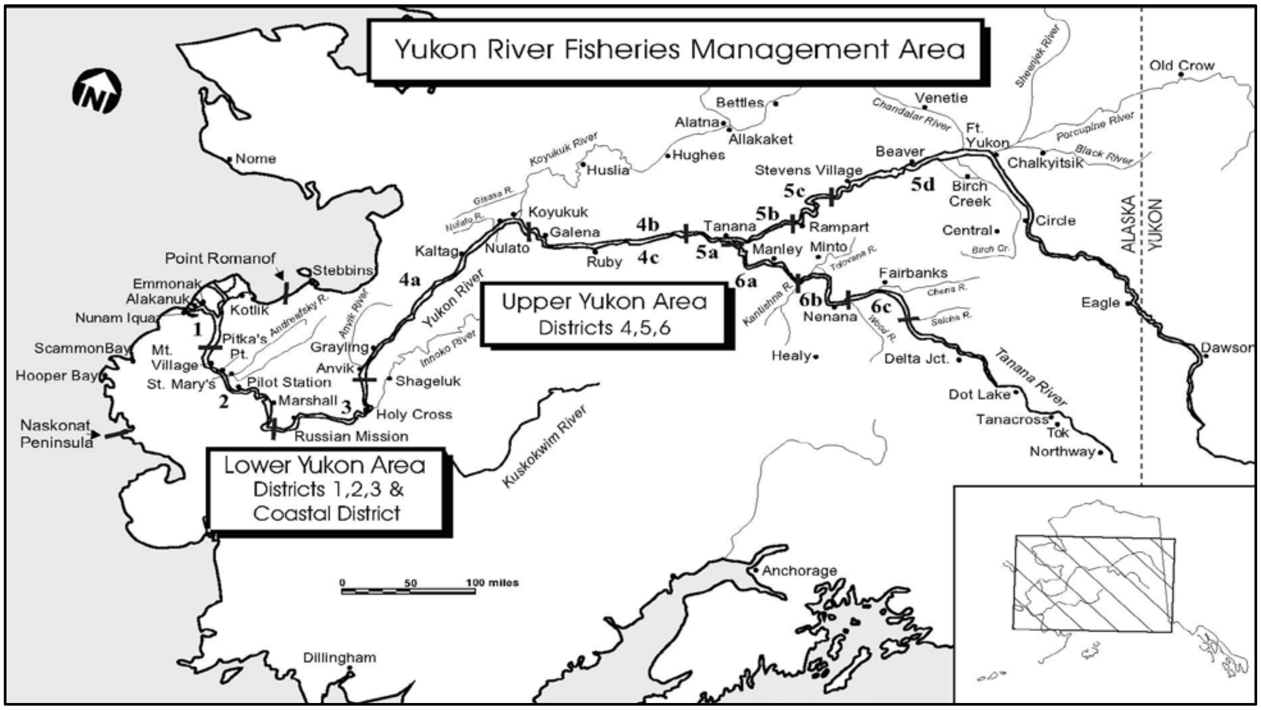


Figure 1.–Fishing districts and communities of the Yukon River drainage.

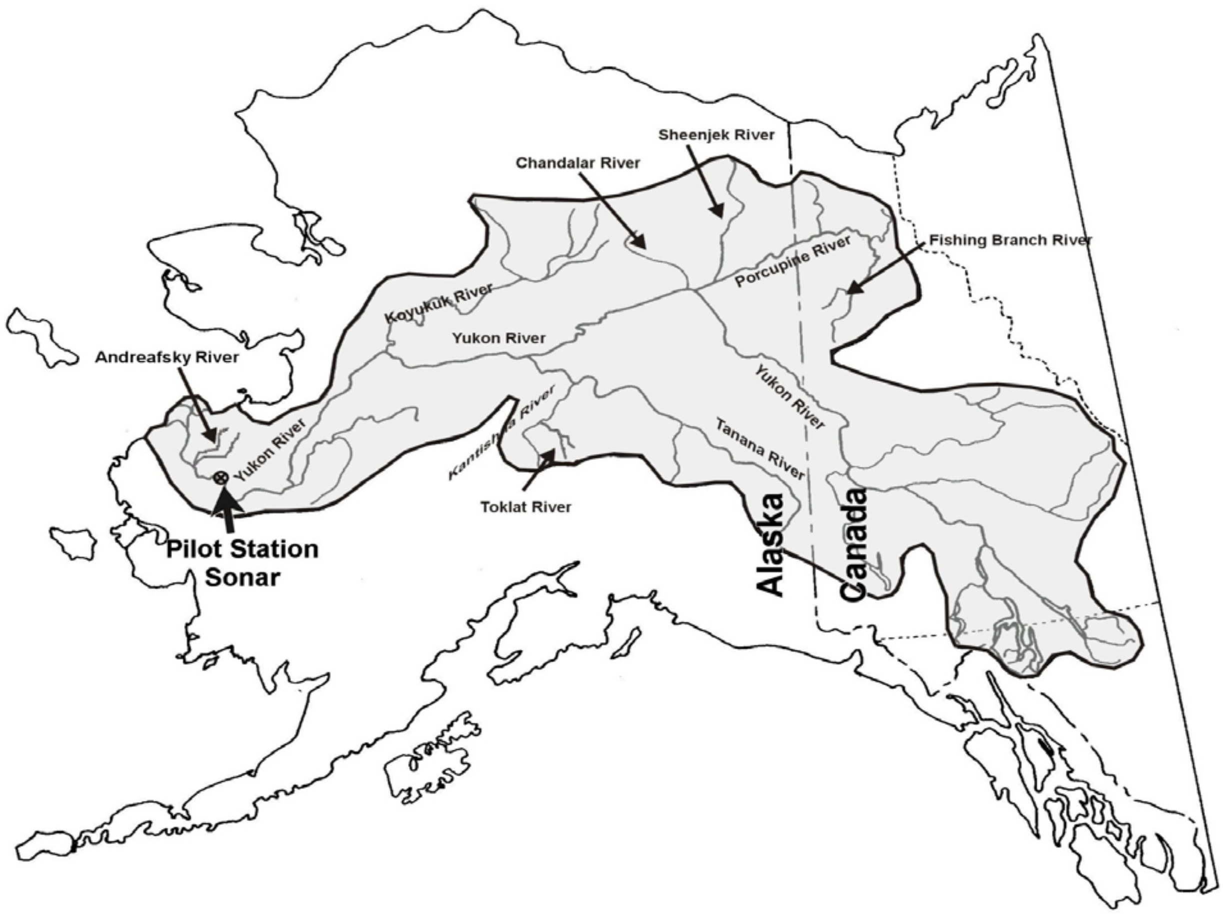


Figure 2.–Extent of the Yukon River watershed.

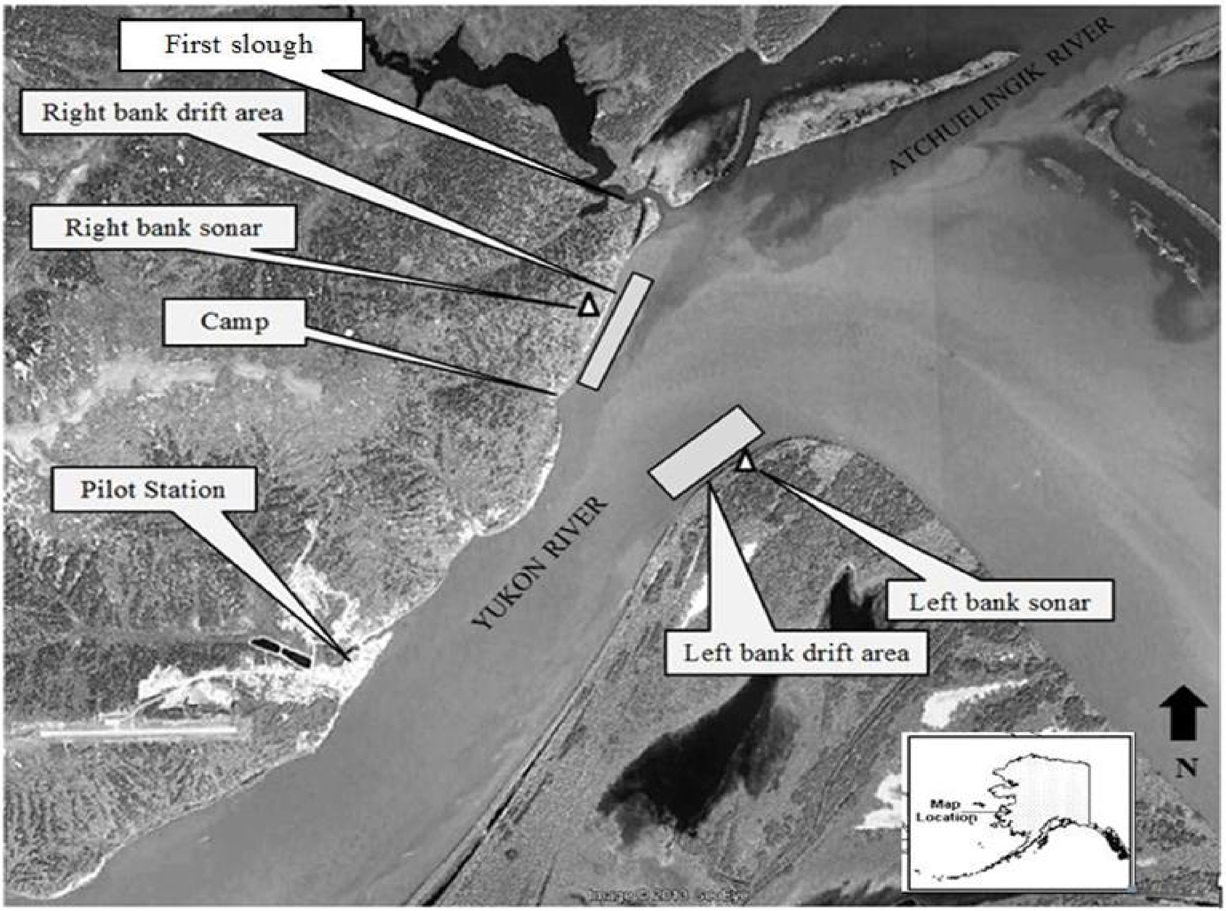


Figure 3.–Location of the Pilot Station sonar project on the Yukon River showing general transducer sites.

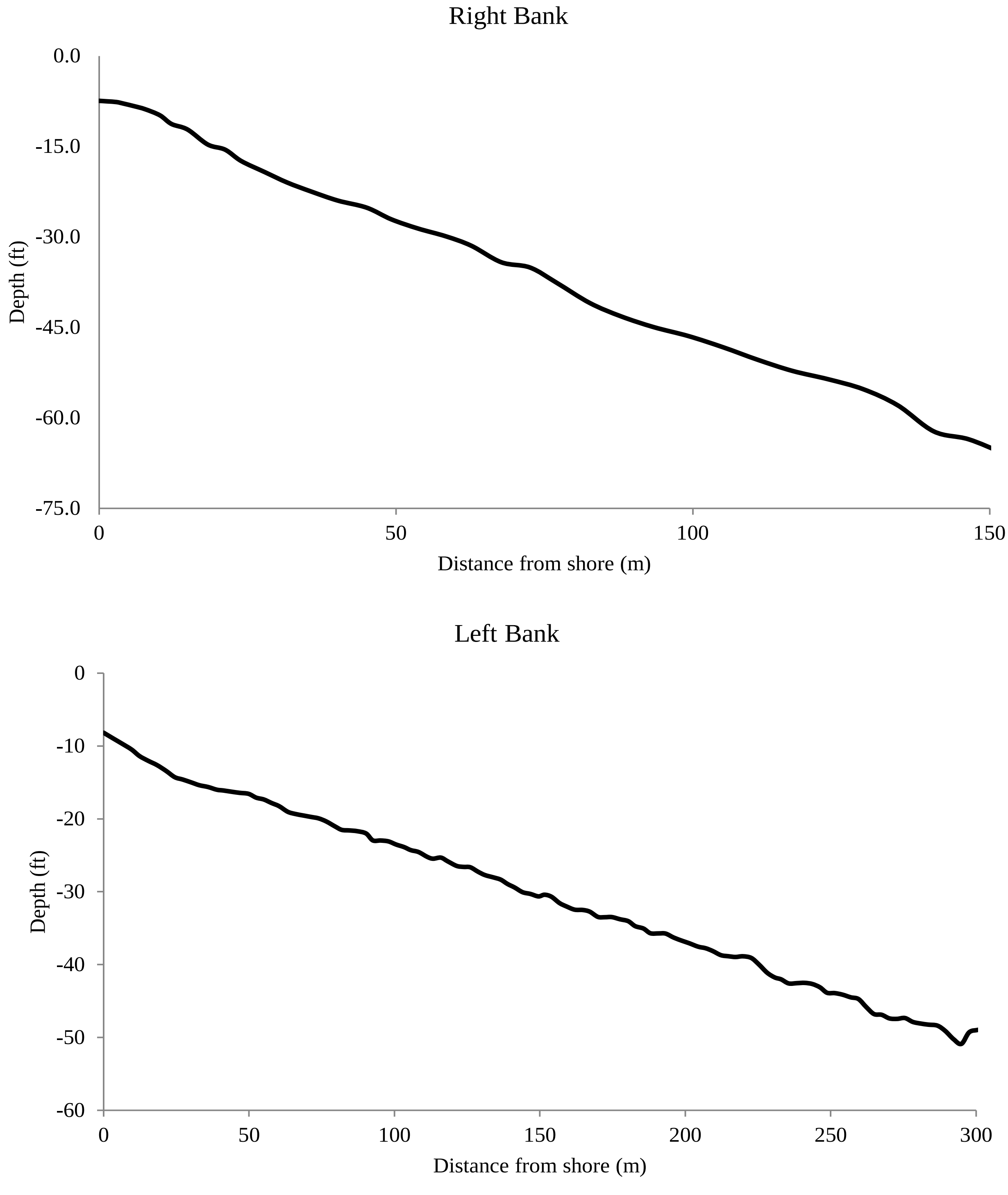


Figure 4.–Bottom profiles for the right bank 2013 (top) and left bank 2014 (bottom), at the Pilot Station sonar project on the Yukon River.

Note: The right bank profile was recorded during the 2013 field season. Due to the rocky bottom, the profile remains stable from year to year.

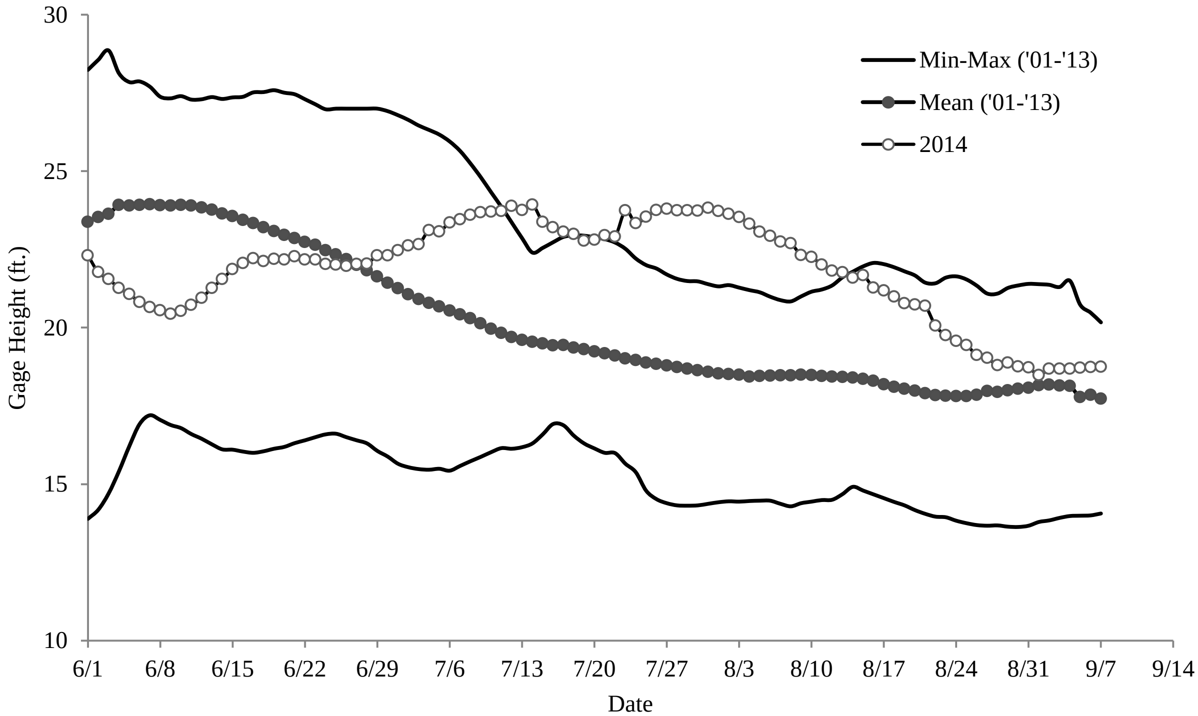


Figure 5.–Yukon River daily water level during the 2014 season at the Pilot Station water gage compared to minimum, maximum, and mean gage height 2001 to 2013.

Source: United States Geological Service.

Note: Missing values were estimated using linear interpolation.

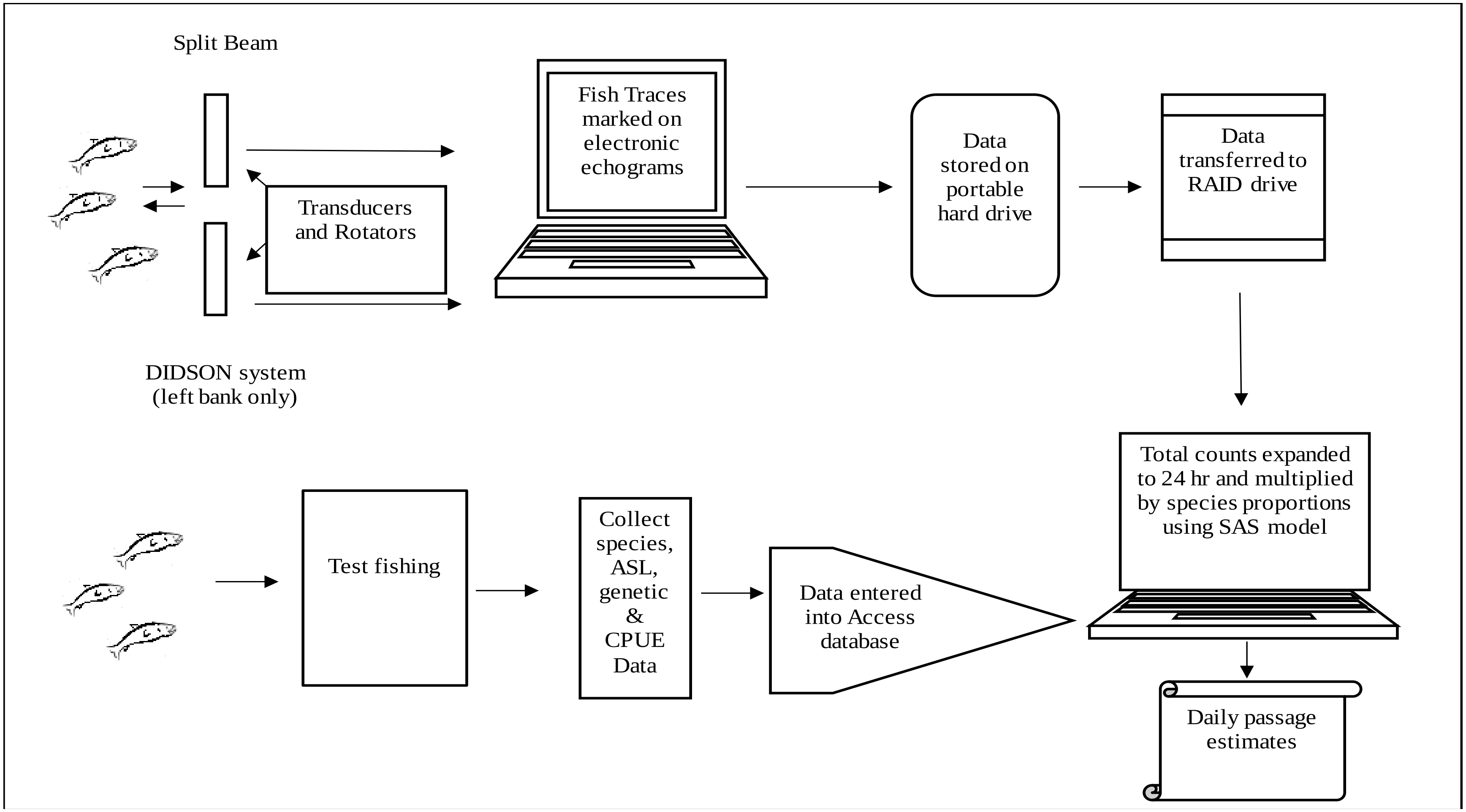


Figure 6.–Flow diagram of data collection and processing, at the Pilot Station sonar project on the Yukon River, 2014.

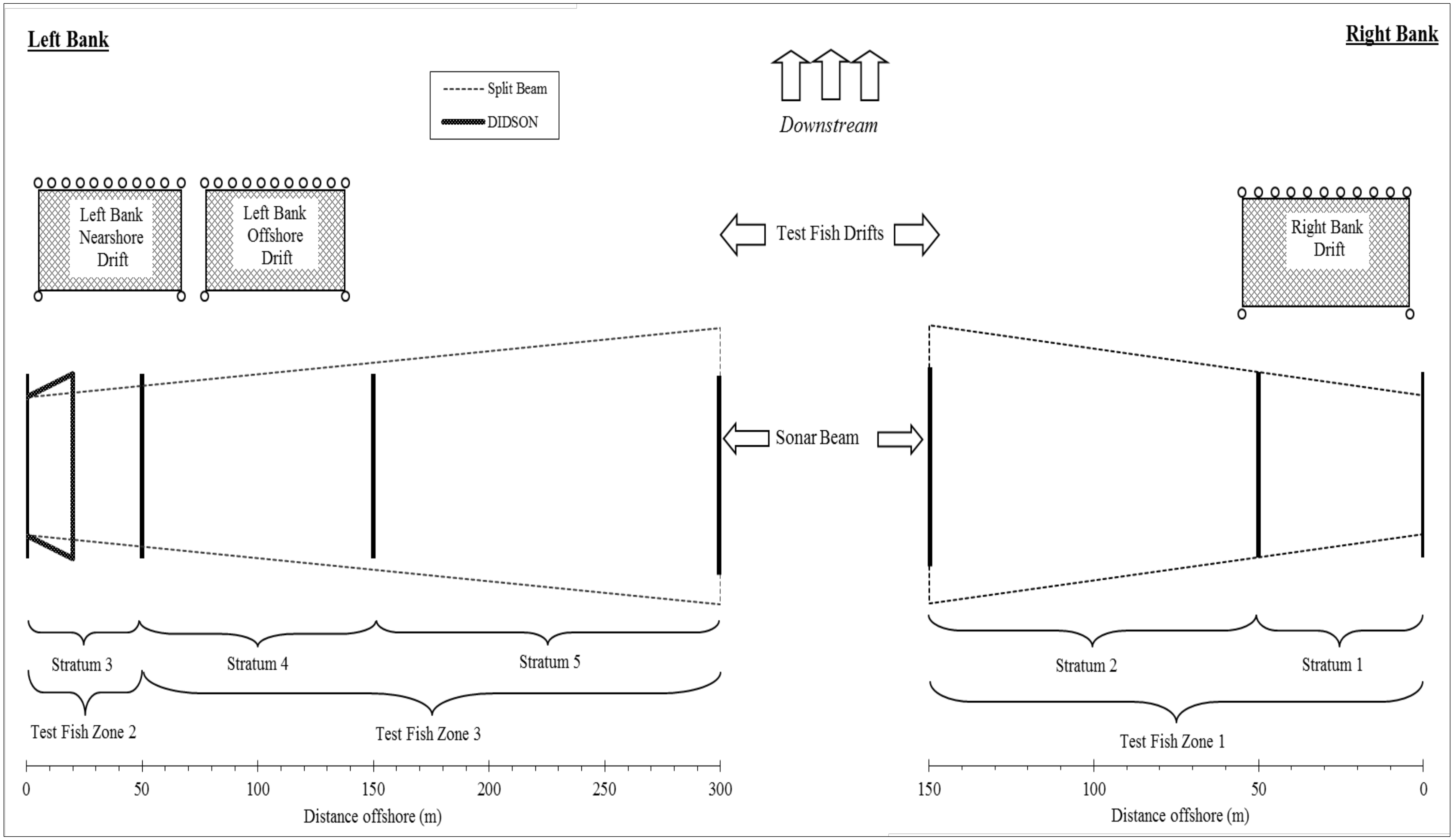


Figure 7.–Illustration of relationships between strata, test fishing zones, test fish drifts, and approximate sonar ranges (not to scale), at the Pilot Station sonar project on the Yukon River, 2014.

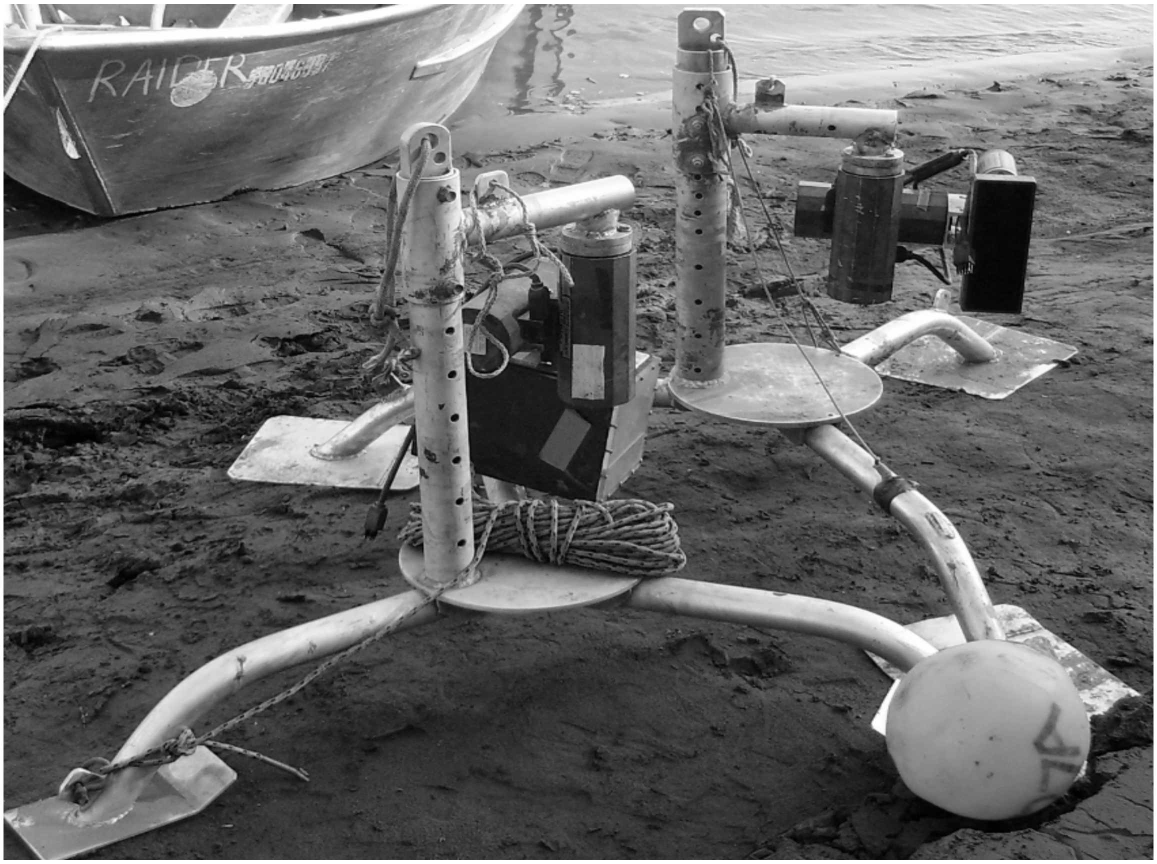


Figure 8.–DIDSON (front) and split-beam transducers mounted to pods with 662H dual axis rotators, at the Pilot Station sonar project on the Yukon River.

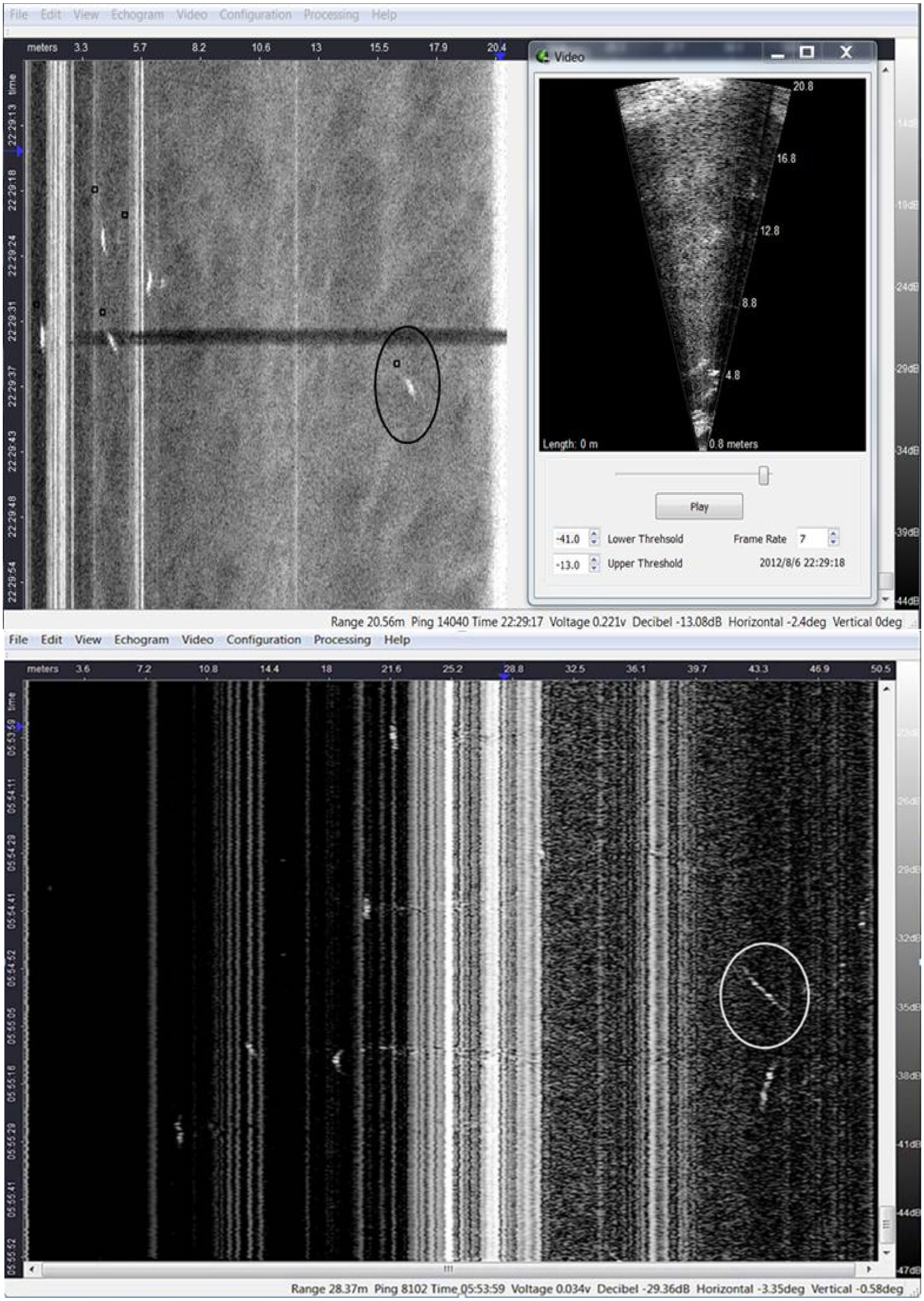
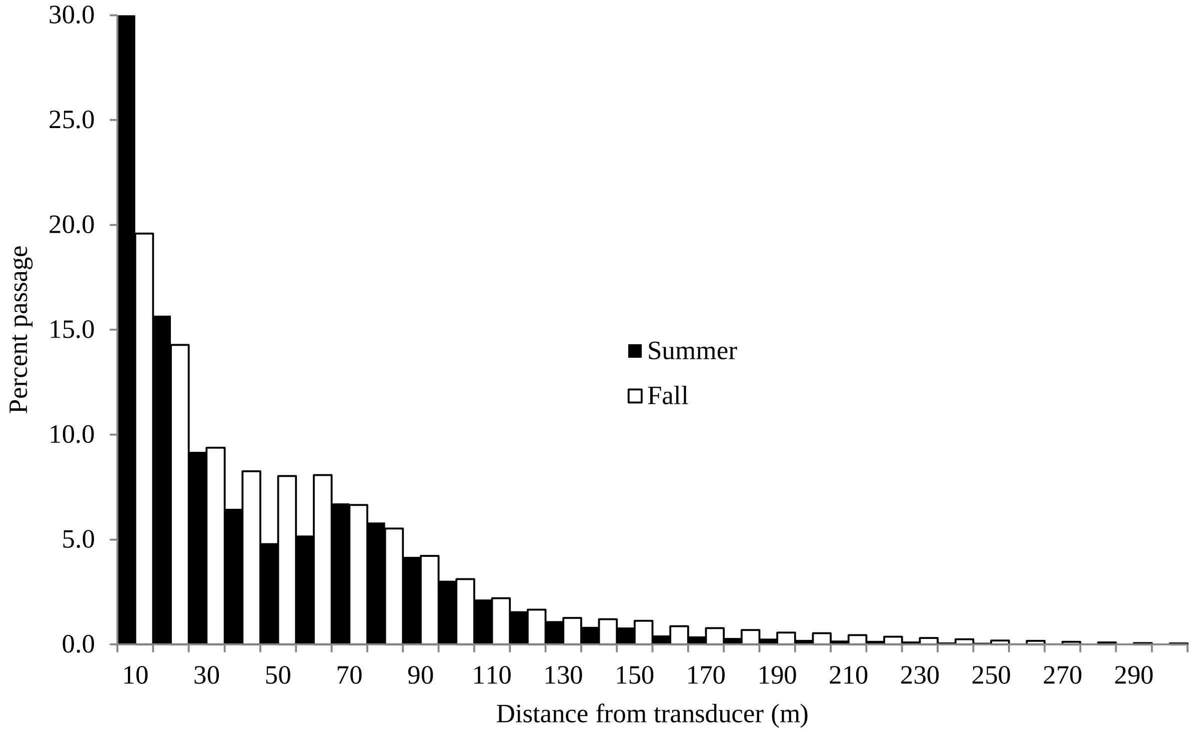


Figure 9.–Echograms of DIDSON alongside video image (top) and split-beam sonar (bottom), with oval around representative fish.

Figure 10.–Mean daily water temperatures, by bank, recorded at the Pilot Station sonar project on the Yukon River with electronic data loggers by bank, 2014.



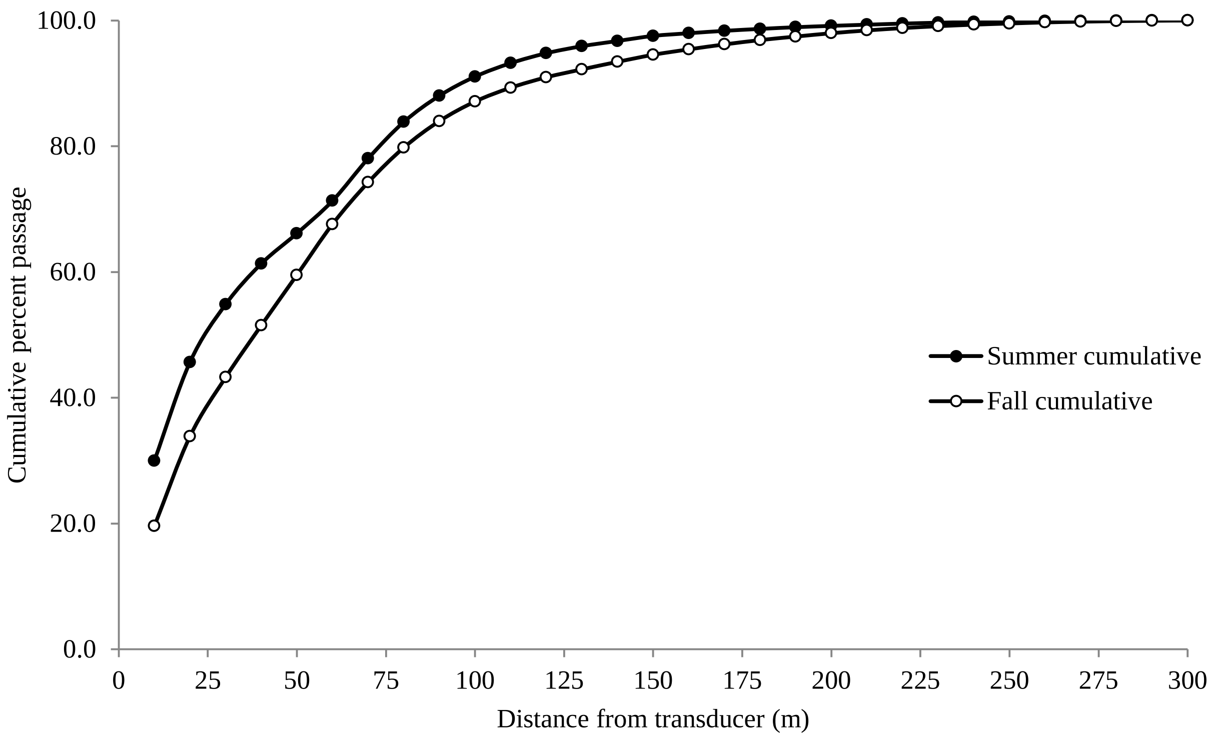
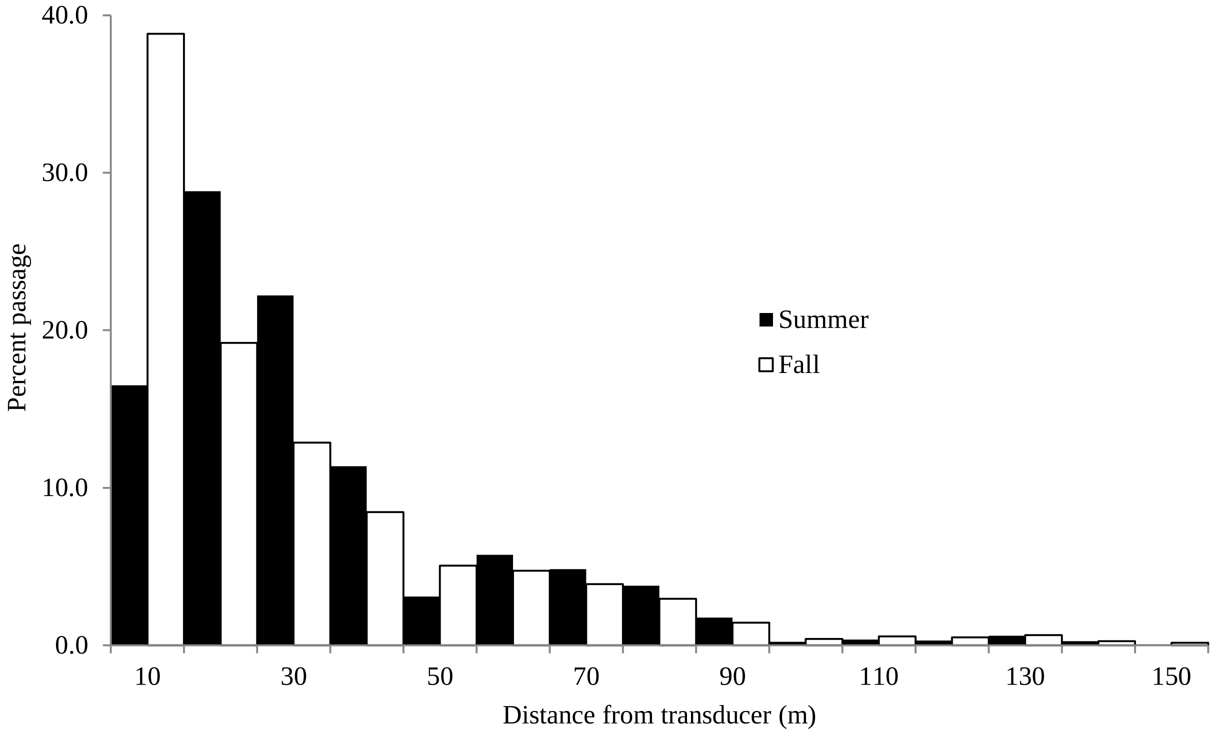


Figure 11.–Distribution of left bank passage (top) and cumulative passage as a function of range (bottom), at the Pilot Station sonar project on the Yukon River, 2014.



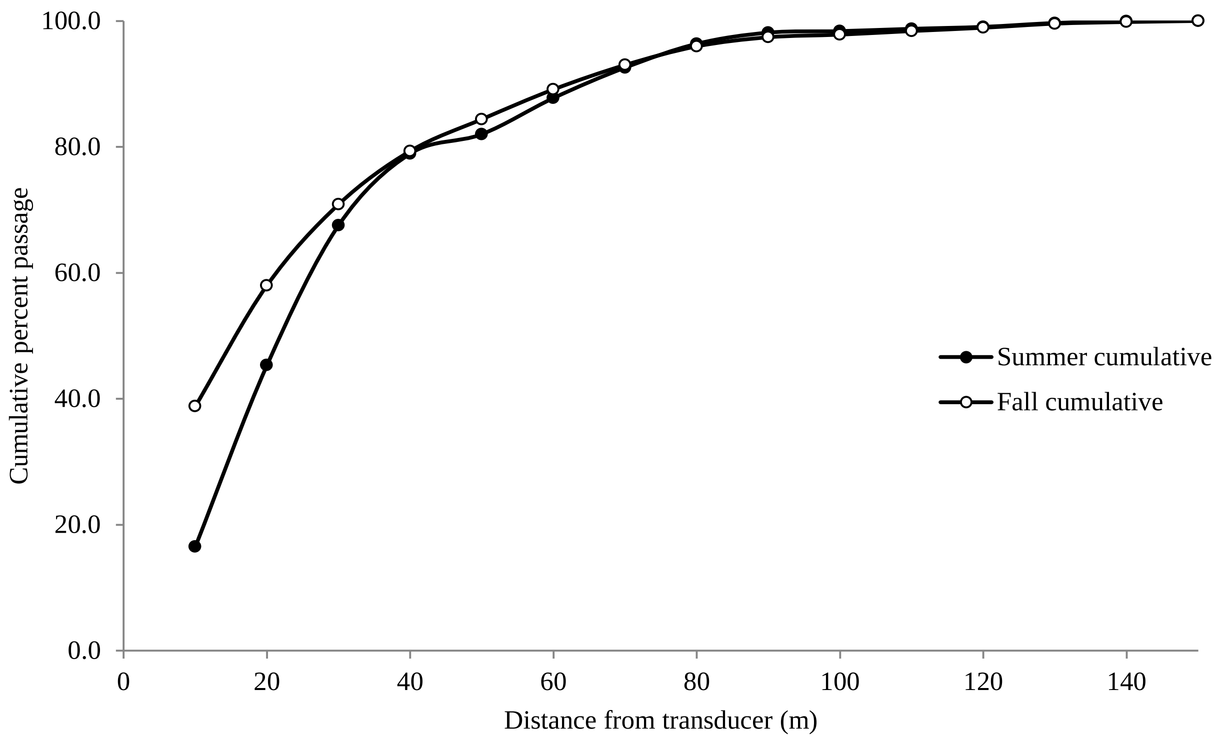


Figure 12.–Distribution of right bank passage (top) and cumulative passage as a function of range (bottom), at the Pilot Station sonar project on the Yukon River, 2014.

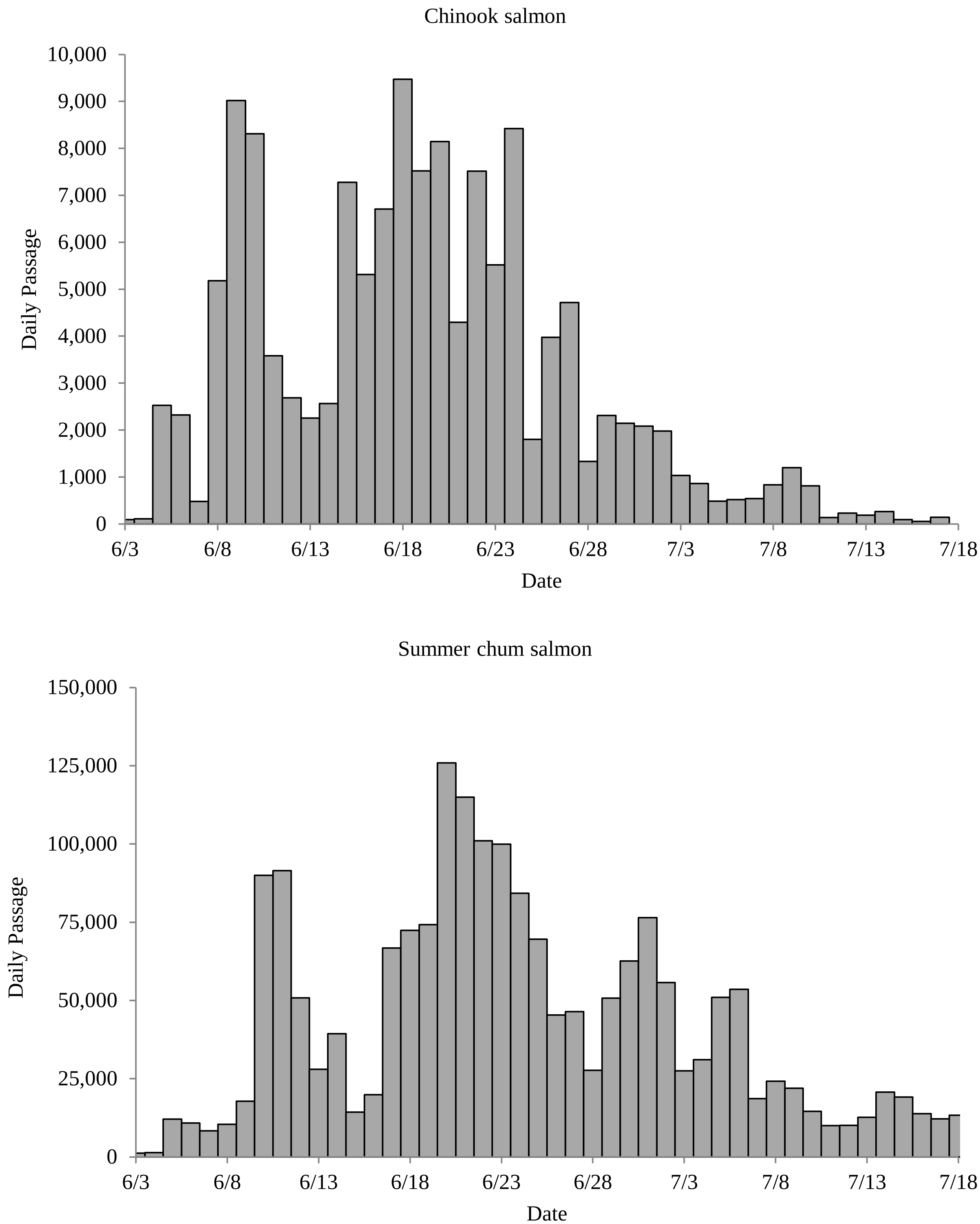
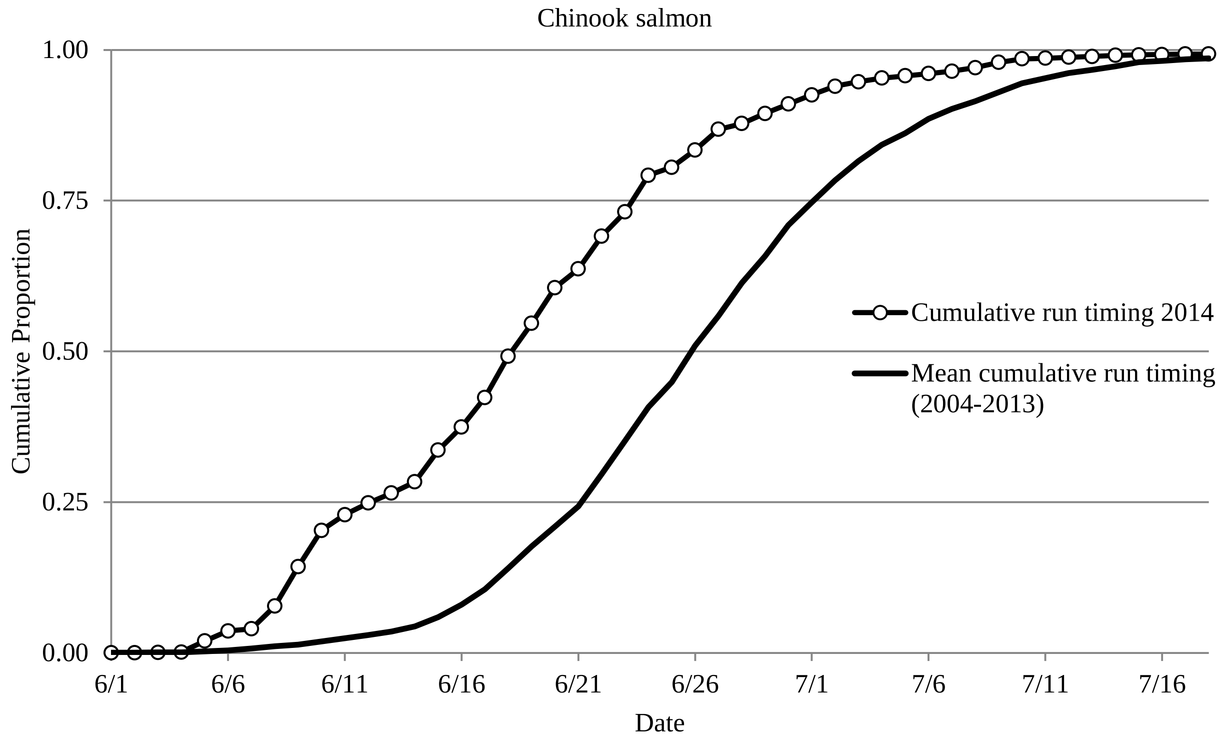


Figure 13.–Chinook and summer chum salmon daily passage estimates, at the Pilot Station sonar project on the Yukon River, 2014.



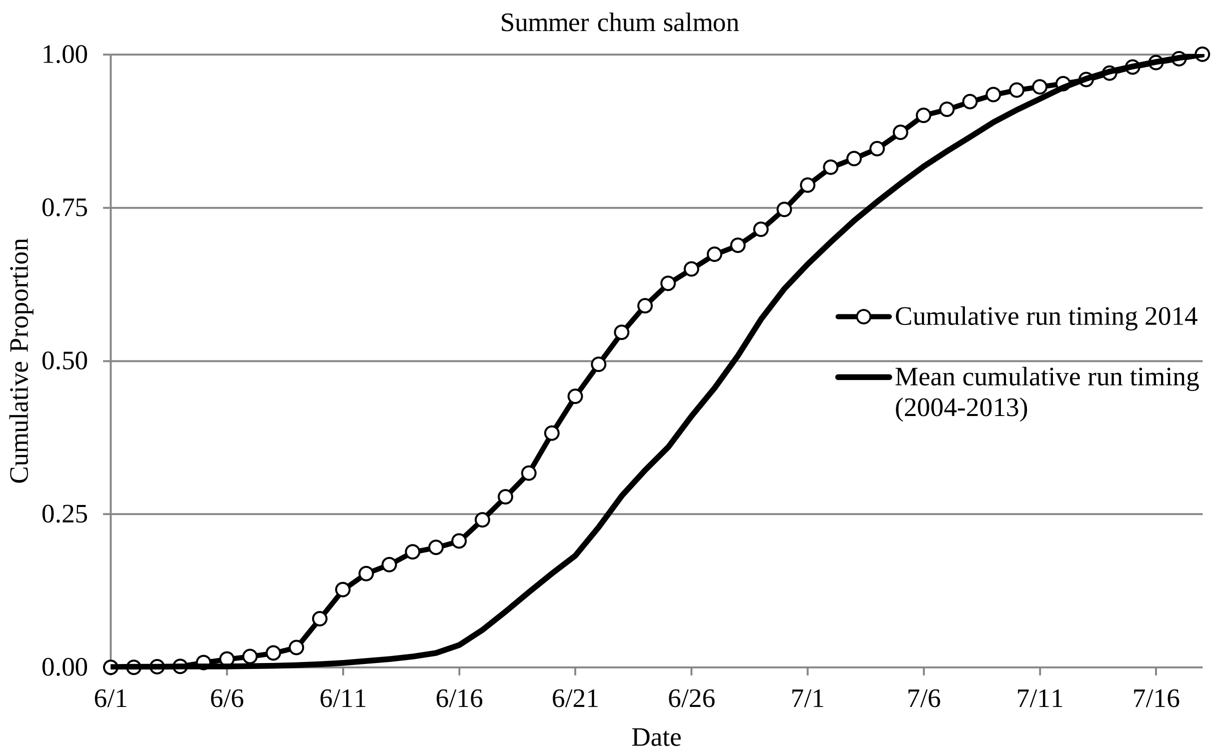


Figure 14.–2014 Chinook and summer chum salmon daily cumulative passage timing compared to the 2004–2013 mean passage timing, at the Pilot Station sonar project on the Yukon River.

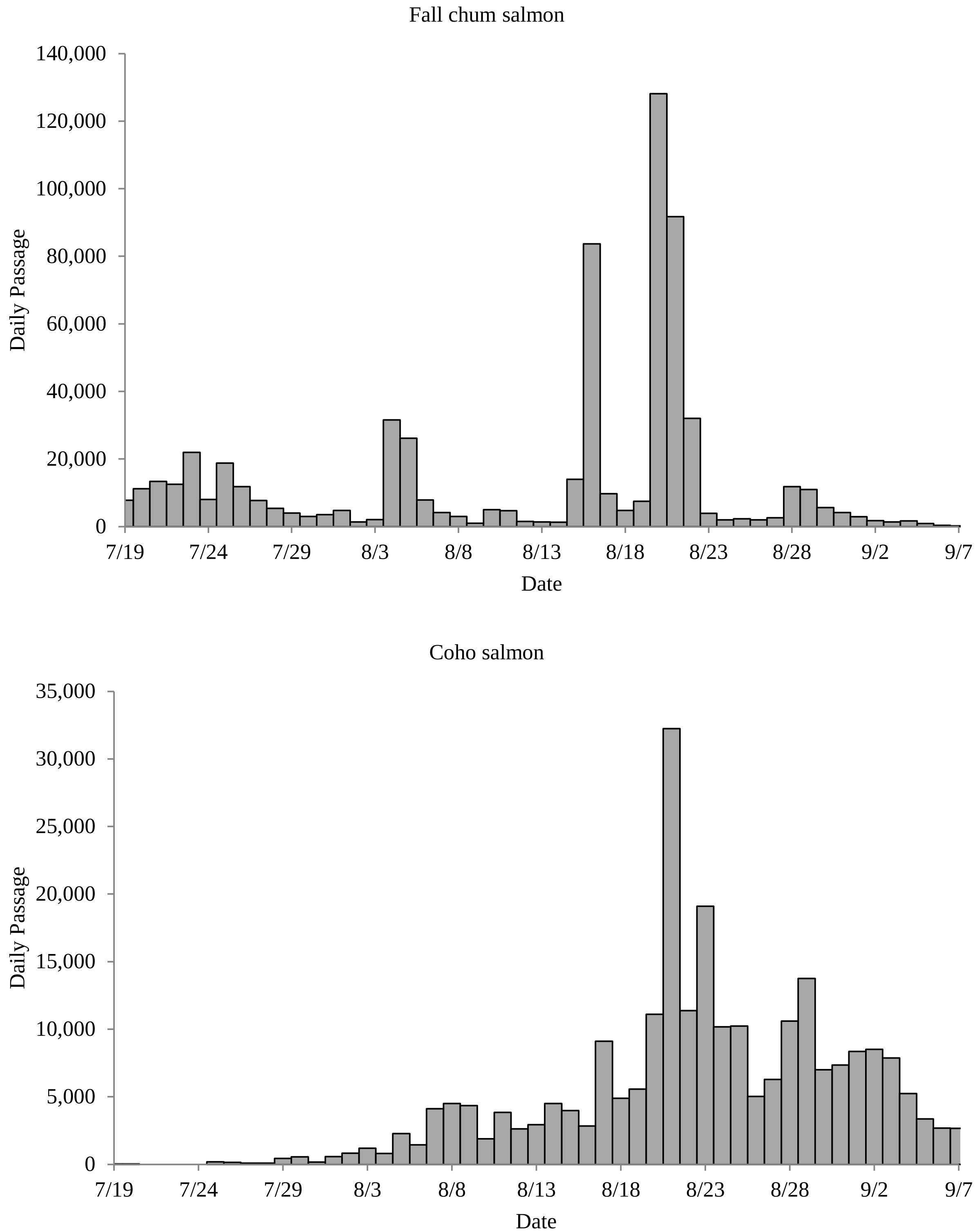


Figure 15.–Fall chum and coho salmon daily passage estimates, at the Pilot Station sonar project on the Yukon River, 2014.

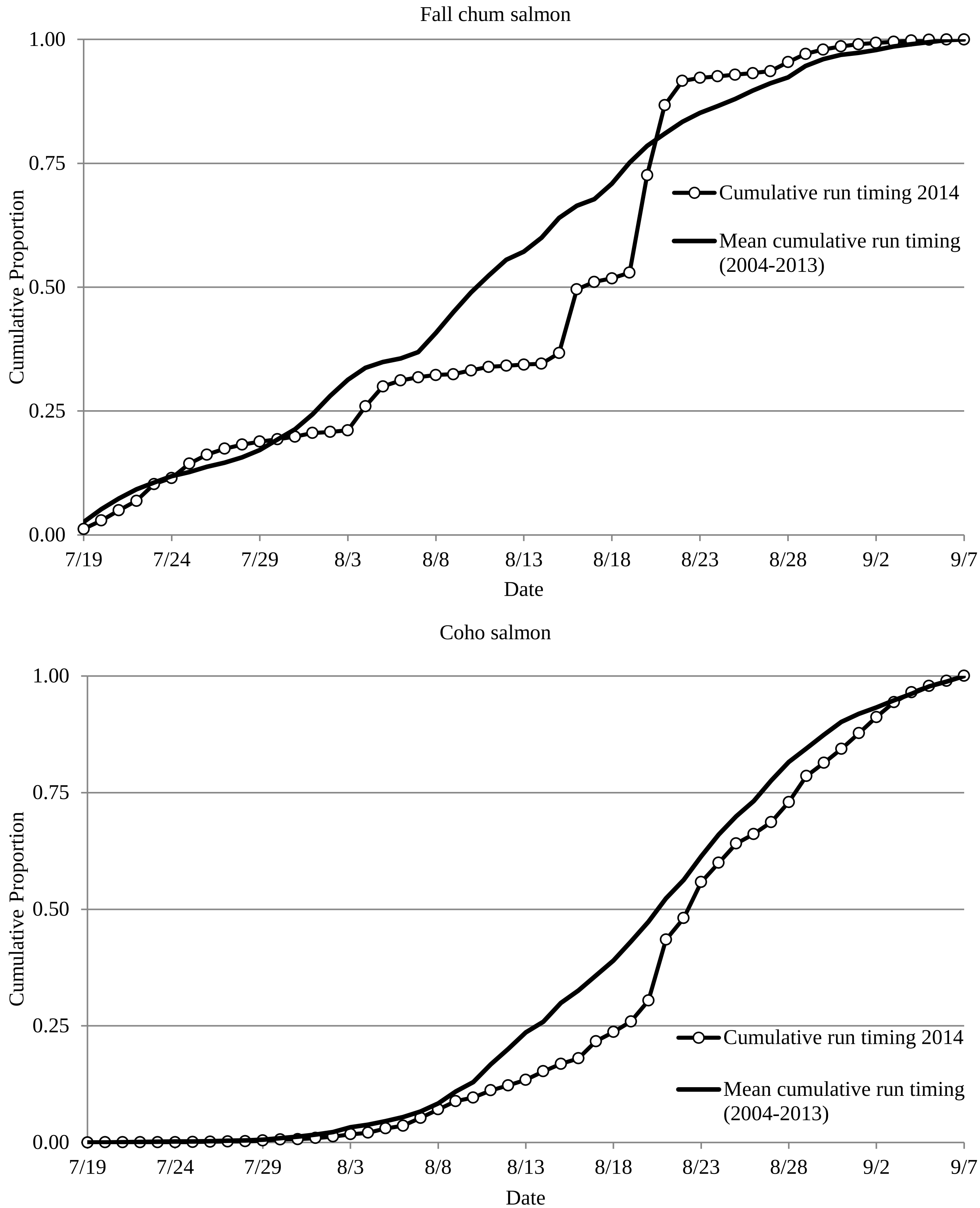


Figure 16.–2014 fall chum and coho salmon daily cumulative passage timing compared to the 2004–2013 mean passage timing, at the Pilot Station sonar project on the Yukon River.

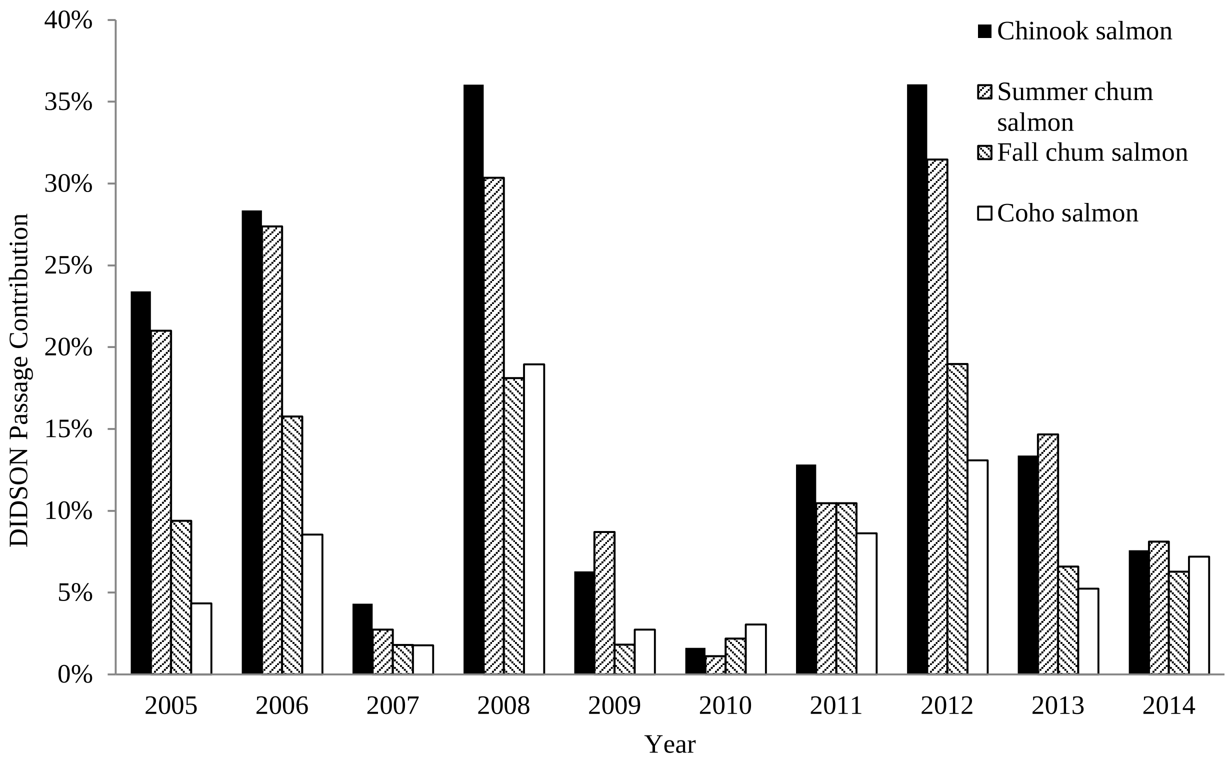


Figure 17.–Percent of total passage by species, contributed by the DIDSON 2005–2014, at the Pilot Station sonar project on the Yukon River.

APPENDIX A: NET SELECTIVITY PARAMETERS USED IN FISH SPECIES APPORTIONMENT AT THE PILOT STATION SONAR PROJECT

Appendix A1.–Net selectivity parameters used in species apportionment, at the Pilot Station sonar project on the Yukon River, 2014.

Species	Tau	Sigma	Theta	Lambda	Tangle
Large Chinook [a]	1.9008	0.2050	0.5923	-0.4334	0.0239
Small Chinook [b]	1.9008	0.2050	0.5923	-0.4334	0.0239
Summer chum	1.9699	0.1543	0.7504	-0.4841	0.0000
Fall chum	1.8632	0.2330	1.1954	-1.4361	0.0303
Coho	1.9827	0.3269	0.8686	-1.4557	0.1185
Pink	1.9805	0.2598	1.5542	1.2820	0.1649
Broad whitefish	1.7774	0.2205	1.4018	-1.9341	0.0981
Humpback whitefish	1.9021	0.2320	1.1103	-2.0546	0.0642
Cisco	2.0830	0.2223	1.8771	-1.6381	0.1809
Other [c]	2.2604	0.3642	0.9881	-2.2990	0.0000

[a] Chinook salmon >655 mm.

[b] Chinook salmon ≤655 mm.

[c] Includes sockeye salmon, cisco, whitefish, sheefish, burbot, longnose sucker, Dolly Varden, and northern pike.

APPENDIX B: SALMON SPECIES CPUE BY DAY AND BANK

Appendix B1.–Left Bank CPUE, by day and salmon species, at the Pilot Station sonar project on the Yukon River, 2014.

	Large mesh	Chinook		Small mesh	Summer chum		Fall chum		Coho	
Date	fathom hours	Catch	CPUE	fathom hours	Catch	CPUE	Catch	CPUE	Catch	CPUE
6/01	11.40	2	0.18	6.15	5	0.81	0	0.00	0	0.00
6/02	21.00	4	0.19	18.07	22	1.22	0	0.00	0	0.00
6/03	17.44	2	0.11	17.67	22	1.25	0	0.00	0	0.00
6/04	18.44	9	0.49	18.22	20	1.10	0	0.00	0	0.00
6/05	18.71	3	0.16	17.97	29	1.61	0	0.00	0	0.00
6/06	17.48	5	0.29	18.30	17	0.93	0	0.00	0	0.00
6/07	17.41	1	0.06	17.57	13	0.74	0	0.00	0	0.00
6/08	17.89	11	0.62	18.36	12	0.65	0	0.00	0	0.00
6/09	10.84	6	0.55	8.68	13	1.50	0	0.00	0	0.00
6/10	11.56	16	1.38	7.18	65	9.06	0	0.00	0	0.00
6/11	13.07	3	0.23	9.01	63	6.99	0	0.00	0	0.00
6/12	16.49	4	0.24	11.62	60	5.16	0	0.00	0	0.00
6/13	15.78	5	0.32	15.33	41	2.67	0	0.00	0	0.00
6/14	16.16	8	0.50	14.36	51	3.55	0	0.00	0	0.00
6/15	17.44	16	0.92	14.26	15	1.05	0	0.00	0	0.00
6/16	16.97	9	0.53	15.82	21	1.33	0	0.00	0	0.00
6/17	13.61	13	0.96	7.65	52	6.80	0	0.00	0	0.00
6/18	14.36	11	0.77	8.30	37	4.46	0	0.00	0	0.00
6/19	13.82	11	0.80	10.09	80	7.93	0	0.00	0	0.00
6/20	9.93	12	1.21	8.77	82	9.35	0	0.00	0	0.00
6/21	13.68	3	0.22	6.86	77	11.23	0	0.00	0	0.00
6/22	13.97	14	1.00	10.14	115	11.34	0	0.00	0	0.00
6/23	15.67	8	0.51	8.07	94	11.65	0	0.00	0	0.00
6/24	13.10	10	0.76	10.25	42	4.10	0	0.00	0	0.00
6/25	17.48	3	0.17	12.31	61	4.96	0	0.00	0	0.00
6/26	16.18	11	0.68	15.20	46	3.03	0	0.00	0	0.00
6/27	16.59	4	0.24	10.85	46	4.24	0	0.00	0	0.00
6/28	16.65	3	0.18	15.37	37	2.41	0	0.00	0	0.00
6/29	16.11	4	0.25	14.48	85	5.87	0	0.00	0	0.00
6/30	16.66	3	0.18	12.07	62	5.14	0	0.00	0	0.00
7/01	14.56	6	0.41	11.26	64	5.68	0	0.00	0	0.00
7/02	17.91	3	0.17	10.79	38	3.52	0	0.00	0	0.00
7/03	17.06	2	0.12	12.65	27	2.13	0	0.00	0	0.00
7/04	17.76	3	0.17	12.93	43	3.32	0	0.00	0	0.00
7/05	14.45	3	0.21	8.85	52	5.87	0	0.00	0	0.00

-continued-

Appendix B1.–Page 2 of 3.

Date	Large mesh fathom hours	Chinook		Small mesh fathom hours	Summer chum		Fall chum		Coho	
		Catch	CPUE		Catch	CPUE	Catch	CPUE	Catch	CPUE
7/06	11.62	0	0.00	7.52	35	4.66	0	0.00	0	0.00
7/07	17.63	1	0.06	17.14	32	1.87	0	0.00	0	0.00
7/08	12.00	0	0.00	9.31	17	1.83	0	0.00	0	0.00
7/09	16.70	1	0.06	15.18	21	1.38	0	0.00	0	0.00
7/10	11.41	1	0.09	10.52	4	0.38	0	0.00	0	0.00
7/11	17.69	0	0.00	17.12	7	0.41	0	0.00	0	0.00
7/12	10.77	1	0.09	9.95	17	1.71	0	0.00	0	0.00
7/13	17.47	1	0.06	15.61	9	0.58	0	0.00	0	0.00
7/14	11.35	1	0.09	10.84	29	2.68	0	0.00	0	0.00
7/15	20.86	0	0.00	17.18	40	2.33	0	0.00	0	0.00
7/16	11.75	0	0.00	10.21	20	1.96	0	0.00	0	0.00
7/17	16.82	0	0.00	16.12	33	2.05	0	0.00	0	0.00
7/18	17.04	0	0.00	16.86	43	2.55	0	0.00	0	0.00
7/19	5.81	0	0.00	15.37	0	0.00	52	3.38	0	0.00
7/20	5.55	0	0.00	11.06	0	0.00	31	2.80	1	0.09
7/21	5.40	0	0.00	16.66	0	0.00	20	1.20	0	0.00
7/22	5.33	0	0.00	16.18	0	0.00	30	1.85	0	0.00
7/23	5.51	0	0.00	15.93	0	0.00	41	2.57	0	0.00
7/24	5.93	0	0.00	17.35	0	0.00	20	1.15	0	0.00
7/25	5.57	0	0.00	16.85	0	0.00	49	2.91	1	0.06
7/26	5.52	0	0.00	17.02	0	0.00	24	1.41	0	0.00
7/27	6.19	0	0.00	11.80	0	0.00	14	1.19	0	0.00
7/28	5.97	0	0.00	17.08	0	0.00	17	1.00	0	0.00
7/29	5.69	0	0.00	16.98	0	0.00	9	0.53	0	0.00
7/30	5.52	0	0.00	17.09	0	0.00	7	0.41	1	0.06
7/31	5.74	0	0.00	16.67	0	0.00	8	0.48	0	0.00
8/01	5.44	0	0.00	17.50	0	0.00	15	0.86	1	0.06
8/02	5.76	0	0.00	17.59	0	0.00	2	0.11	0	0.00
8/03	6.12	0	0.00	11.92	0	0.00	3	0.25	1	0.08
8/04	4.92	0	0.00	16.51	0	0.00	50	3.03	2	0.12
8/05	5.34	0	0.00	16.10	0	0.00	32	1.99	4	0.25
8/06	5.64	0	0.00	16.67	0	0.00	15	0.90	1	0.06
8/07	5.89	0	0.00	16.71	0	0.00	4	0.24	3	0.18
8/08	5.88	0	0.00	16.59	0	0.00	6	0.36	1	0.06
8/09	5.57	0	0.00	17.56	0	0.00	2	0.11	5	0.28

-continued-

Appendix B1.–Page 3 of 3.

Date	Large mesh fathom hours	Chinook Catch	Chinook CPUE	Small mesh fathom hours	Summer chum Catch	Summer chum CPUE	Fall chum Catch	Fall chum CPUE	Coho Catch	Coho CPUE
8/10	6.10	0	0.00	17.69	0	0.00	14	0.79	2	0.11
8/11	5.89	0	0.00	17.04	0	0.00	14	0.82	8	0.47
8/12	5.84	0	0.00	17.18	0	0.00	5	0.29	4	0.23
8/13	5.39	0	0.00	17.75	0	0.00	2	0.11	6	0.34
8/14	5.46	0	0.00	18.03	0	0.00	1	0.06	4	0.22
8/15	5.69	0	0.00	17.18	0	0.00	44	2.56	9	0.52
8/16	2.30	0	0.00	7.08	0	0.00	92	12.99	5	0.71
8/17	5.88	0	0.00	14.72	0	0.00	19	1.29	9	0.61
8/18	5.77	0	0.00	11.57	0	0.00	7	0.60	6	0.52
8/19	6.15	0	0.00	17.45	0	0.00	10	0.57	10	0.57
8/20	2.77	0	0.00	12.13	0	0.00	86	7.09	7	0.58
8/21	3.97	0	0.00	7.08	0	0.00	78	11.02	10	1.41
8/22	5.70	0	0.00	6.99	0	0.00	27	3.86	22	3.15
8/23	5.57	0	0.00	16.20	0	0.00	5	0.31	29	1.79
8/24	5.56	0	0.00	11.48	0	0.00	2	0.17	10	0.87
8/25	5.73	0	0.00	17.08	0	0.00	5	0.29	14	0.82
8/26	5.96	0	0.00	17.39	0	0.00	2	0.12	14	0.81
8/27	3.92	0	0.00	10.10	0	0.00	4	0.40	5	0.50
8/28	5.57	0	0.00	17.88	0	0.00	13	0.73	12	0.67
8/29	5.62	0	0.00	16.85	0	0.00	24	1.42	20	1.19
8/30	5.10	0	0.00	9.88	0	0.00	3	0.30	9	0.91
8/31	6.40	0	0.00	17.38	0	0.00	7	0.40	9	0.52
9/01	6.09	0	0.00	16.28	0	0.00	5	0.31	13	0.80
9/02	5.51	0	0.00	17.99	0	0.00	4	0.22	19	1.06
9/03	5.26	0	0.00	17.08	0	0.00	2	0.12	13	0.76
9/04	5.49	0	0.00	16.48	0	0.00	3	0.18	10	0.61
9/05	6.05	0	0.00	17.72	0	0.00	2	0.11	8	0.45
9/06	5.79	0	0.00	17.72	0	0.00	2	0.11	8	0.45
9/07	5.56	0	0.00	17.97	0	0.00	0	0.00	3	0.17
Total	1,021.12	237	16.23	1,399.58	1,916	177.04	933	75.97	319	23.12

Appendix B2.–Right bank CPUE, by day and salmon species, at the Pilot Station sonar project on the Yukon River, 2014.

	Large mesh	Chinook		Small mesh	Summer chum		Fall chum		Coho	
Date	fathom hours	Catch	CPUE	fathom hours	Catch	CPUE	Catch	CPUE	Catch	CPUE
6/01	5.68	0	0.00	2.87	1	0.35	0	0.00	0	0.00
6/02	9.21	1	0.11	7.93	0	0.00	0	0.00	0	0.00
6/03	9.00	0	0.00	7.73	1	0.13	0	0.00	0	0.00
6/04	8.24	0	0.00	8.53	2	0.23	0	0.00	0	0.00
6/05	8.74	0	0.00	8.21	10	1.22	0	0.00	0	0.00
6/06	8.19	1	0.12	8.44	3	0.36	0	0.00	0	0.00
6/07	8.57	0	0.00	8.52	4	0.47	0	0.00	0	0.00
6/08	8.67	1	0.12	8.25	4	0.48	0	0.00	0	0.00
6/09	5.56	2	0.36	5.18	5	0.97	0	0.00	0	0.00
6/10	7.84	3	0.38	3.92	37	9.44	0	0.00	0	0.00
6/11	6.72	5	0.74	4.39	24	5.47	0	0.00	0	0.00
6/12	8.06	0	0.00	6.15	29	4.71	0	0.00	0	0.00
6/13	7.90	3	0.38	7.94	22	2.77	0	0.00	0	0.00
6/14	8.33	1	0.12	6.18	29	4.69	0	0.00	0	0.00
6/15	8.03	0	0.00	7.94	24	3.02	0	0.00	0	0.00
6/16	8.52	2	0.23	7.40	32	4.33	0	0.00	0	0.00
6/17	5.89	1	0.17	3.89	22	5.65	0	0.00	0	0.00
6/18	6.42	3	0.47	4.69	26	5.54	0	0.00	0	0.00
6/19	6.36	3	0.47	3.48	23	6.62	0	0.00	0	0.00
6/20	5.48	0	0.00	3.08	32	10.40	0	0.00	0	0.00
6/21	5.98	1	0.17	2.98	24	8.07	0	0.00	0	0.00
6/22	6.86	0	0.00	4.17	25	5.99	0	0.00	0	0.00
6/23	5.88	2	0.34	3.23	28	8.68	0	0.00	0	0.00
6/24	7.21	7	0.97	4.26	26	6.10	0	0.00	0	0.00
6/25	7.34	1	0.14	5.73	29	5.06	0	0.00	0	0.00
6/26	7.66	6	0.78	7.11	40	5.62	0	0.00	0	0.00
6/27	8.10	2	0.25	6.06	31	5.12	0	0.00	0	0.00
6/28	8.27	0	0.00	7.92	31	3.91	0	0.00	0	0.00
6/29	7.62	0	0.00	7.13	11	1.54	0	0.00	0	0.00
6/30	7.91	0	0.00	6.00	30	5.00	0	0.00	0	0.00
7/01	7.86	0	0.00	4.98	73	14.65	0	0.00	0	0.00
7/02	8.55	0	0.00	5.25	32	6.09	0	0.00	0	0.00
7/03	8.07	0	0.00	5.68	10	1.76	0	0.00	0	0.00
7/04	8.25	0	0.00	5.72	18	3.15	0	0.00	0	0.00
7/05	7.59	0	0.00	5.29	16	3.02	0	0.00	0	0.00

-continued-

Appendix B2.–Page 2 of 3.

Date	Large mesh fathom hours	Chinook Catch	Chinook CPUE	Small mesh fathom hours	Summer chum Catch	Summer chum CPUE	Fall chum Catch	Fall chum CPUE	Coho Catch	Coho CPUE
7/06	5.45	0	0.00	3.29	27	8.21	0	0.00	0	0.00
7/07	7.68	0	0.00	6.72	7	1.04	0	0.00	0	0.00
7/08	4.84	0	0.00	4.53	22	4.86	0	0.00	0	0.00
7/09	7.81	0	0.00	7.89	1	0.13	0	0.00	0	0.00
7/10	4.93	0	0.00	5.15	10	1.94	0	0.00	0	0.00
7/11	8.42	0	0.00	7.69	7	0.91	0	0.00	0	0.00
7/12	4.13	0	0.00	4.55	16	3.52	0	0.00	0	0.00
7/13	8.03	0	0.00	7.54	6	0.80	0	0.00	0	0.00
7/14	5.84	0	0.00	5.27	20	3.79	0	0.00	0	0.00
7/15	8.17	0	0.00	8.10	12	1.48	0	0.00	0	0.00
7/16	5.53	0	0.00	4.85	3	0.62	0	0.00	0	0.00
7/17	7.82	0	0.00	7.78	4	0.51	0	0.00	0	0.00
7/18	8.12	0	0.00	8.09	28	3.46	0	0.00	0	0.00
7/19	2.85	1	0.35	7.75	0	0.00	9	1.16	0	0.00
7/20	2.58	0	0.00	5.27	0	0.00	7	1.33	0	0.00
7/21	3.14	0	0.00	8.88	0	0.00	5	0.56	0	0.00
7/22	2.89	0	0.00	8.01	0	0.00	5	0.62	0	0.00
7/23	2.38	0	0.00	8.17	0	0.00	16	1.96	0	0.00
7/24	2.53	0	0.00	8.24	0	0.00	3	0.36	0	0.00
7/25	2.66	0	0.00	7.79	0	0.00	6	0.77	0	0.00
7/26	2.84	0	0.00	7.61	0	0.00	5	0.66	0	0.00
7/27	3.18	0	0.00	5.65	0	0.00	3	0.53	0	0.00
7/28	2.58	0	0.00	7.93	0	0.00	9	1.13	1	0.13
7/29	3.19	0	0.00	8.43	0	0.00	4	0.47	1	0.12
7/30	2.64	0	0.00	8.10	0	0.00	1	0.12	0	0.00
7/31	2.97	0	0.00	8.25	0	0.00	3	0.36	2	0.24
8/01	2.81	0	0.00	7.97	0	0.00	2	0.25	0	0.00
8/02	2.69	0	0.00	8.06	0	0.00	2	0.25	0	0.00
8/03	2.48	0	0.00	5.65	0	0.00	2	0.35	0	0.00
8/04	2.82	0	0.00	7.00	0	0.00	3	0.43	0	0.00
8/05	2.75	0	0.00	8.25	0	0.00	4	0.48	3	0.36
8/06	2.78	0	0.00	8.24	0	0.00	2	0.24	2	0.24
8/07	3.03	0	0.00	6.87	0	0.00	0	0.00	0	0.00
8/08	2.40	0	0.00	7.99	0	0.00	0	0.00	0	0.00
8/09	3.02	0	0.00	8.05	0	0.00	1	0.12	1	0.12

-continued-

Appendix B2.–Page 3 of 3.

	Large mesh	Chinook		Small mesh	Summer chum		Fall chum		Coho	
Date	fathom hours	Catch	CPUE	fathom hours	Catch	CPUE	Catch	CPUE	Catch	CPUE
8/10	2.90	0	0.00	8.77	0	0.00	2	0.23	1	0.11
8/11	2.76	0	0.00	8.50	0	0.00	3	0.35	2	0.24
8/12	2.63	0	0.00	8.08	0	0.00	0	0.00	0	0.00
8/13	2.90	0	0.00	8.40	0	0.00	0	0.00	0	0.00
8/14	2.59	0	0.00	8.37	0	0.00	2	0.24	2	0.24
8/15	2.93	0	0.00	8.44	0	0.00	13	1.54	9	1.07
8/16	2.96	0	0.00	7.09	0	0.00	18	2.54	3	0.42
8/17	3.21	0	0.00	8.39	0	0.00	1	0.12	1	0.12
8/18	2.47	0	0.00	5.55	0	0.00	2	0.36	4	0.72
8/19	2.85	0	0.00	8.27	0	0.00	2	0.24	0	0.00
8/20	1.15	0	0.00	5.43	0	0.00	29	5.34	4	0.74
8/21	2.81	0	0.00	6.74	0	0.00	18	2.67	6	0.89
8/22	2.63	0	0.00	5.24	0	0.00	2	0.38	6	1.14
8/23	2.90	0	0.00	8.82	0	0.00	1	0.11	19	2.15
8/24	2.07	0	0.00	5.35	0	0.00	0	0.00	8	1.50
8/25	2.63	0	0.00	8.76	0	0.00	0	0.00	9	1.03
8/26	2.64	0	0.00	8.36	0	0.00	3	0.36	6	0.72
8/27	1.87	0	0.00	5.03	0	0.00	2	0.40	6	1.19
8/28	2.44	0	0.00	8.74	0	0.00	4	0.46	7	0.80
8/29	2.81	0	0.00	7.66	0	0.00	10	1.30	8	1.04
8/30	2.50	0	0.00	4.50	0	0.00	1	0.22	2	0.44
8/31	2.71	0	0.00	8.34	0	0.00	4	0.48	6	0.72
9/01	2.79	0	0.00	8.15	0	0.00	5	0.61	1	0.12
9/02	2.68	0	0.00	8.38	0	0.00	2	0.24	10	1.19
9/03	2.89	0	0.00	7.78	0	0.00	1	0.13	11	1.41
9/04	2.61	0	0.00	7.65	0	0.00	1	0.13	4	0.52
9/05	2.48	0	0.00	8.33	0	0.00	2	0.24	4	0.48
9/06	2.93	0	0.00	8.40	0	0.00	0	0.00	2	0.24
9/07	2.60	0	0.00	8.82	0	0.00	0	0.00	4	0.45
Total	488.88	46	6.67	676.18	917	181.88	220	30.84	155	20.90

APPENDIX C: DAILY FISH PASSAGE ESTIMATES BY ZONE WITH STANDARD ERRORS

Appendix C1.–Daily fish passage estimates by zone with standard errors (SE), at the Pilot Station sonar project on the Yukon River, 2014.

Date	Right bank	Left bank		Total		Percent by bank	
		Nearshore	Offshore	Passage	SE	Right	Left
6/03	3,296	0	0	3,296	1,144	100.0	0.0
6/04	3,884	0	0	3,884	1,241	100.0	0.0
6/05	3,915	8,995	6,511	19,421	20,780	20.2	79.8
6/06	3,656	12,627	3,404	19,687	4,535	18.6	81.4
6/07	4,061	11,048	3,036	18,145	4,043	22.4	77.6
6/08	3,932	14,262	3,083	21,277	4,895	18.5	81.5
6/09	5,749	24,801	5,609	36,159	6,445	15.9	84.1
6/10	17,054	61,258	22,240	100,552	9,844	17.0	83.0
6/11	17,931	65,026	17,199	100,156	14,608	17.9	82.1
6/12	10,749	35,276	12,550	58,575	10,215	18.4	81.7
6/13	10,512	17,202	11,807	39,521	8,880	26.6	73.4
6/14	8,862	26,446	7,890	43,198	4,005	20.5	79.5
6/15	6,209	12,263	7,360	25,832	3,289	24.0	76.0
6/16	7,542	8,480	10,734	26,756	4,965	28.2	71.8
6/17	16,509	27,044	35,514	79,067	12,434	20.9	79.1
6/18	13,582	38,652	32,455	84,689	12,635	16.0	84.0
6/19	17,793	36,294	37,070	91,157	12,361	19.5	80.5
6/20	26,696	57,207	57,781	141,684	20,728	18.8	81.2
6/21	20,890	56,462	48,355	125,707	18,281	16.6	83.4
6/22	28,775	45,763	48,427	122,965	14,620	23.4	76.6
6/23	24,299	48,760	56,716	129,775	13,357	18.7	81.3
6/24	25,515	37,482	37,571	100,568	10,364	25.4	74.6
6/25	24,686	32,537	41,476	98,699	9,926	25.0	75.0
6/26	26,542	28,503	34,133	89,178	17,078	29.8	70.2
6/27	17,273	27,845	24,830	69,948	8,122	24.7	75.3
6/28	11,815	17,009	13,577	42,401	5,431	27.9	72.1
6/29	12,863	30,789	24,235	67,887	9,604	19.0	81.0
6/30	18,894	45,157	24,272	88,323	7,776	21.4	78.6
7/01	21,983	60,246	28,490	110,719	20,094	19.9	80.2
7/02	16,040	36,923	22,077	75,040	8,926	21.4	78.6
7/03	10,841	24,083	10,285	45,209	5,117	24.0	76.0
7/04	12,259	28,795	13,504	54,558	8,097	22.5	77.5
7/05	16,522	46,404	15,469	78,395	16,072	21.1	78.9
7/06	13,570	51,062	17,261	81,893	16,741	16.6	83.4
7/07	10,993	42,929	8,458	62,380	16,758	17.6	82.4
7/08	11,981	67,935	6,487	86,403	20,669	13.9	86.1
7/09	11,297	86,238	7,851	105,386	22,492	10.7	89.3
7/10	9,640	49,871	6,335	65,846	17,206	14.6	85.6
7/11	7,100	27,327	3,396	37,823	6,620	18.8	81.2
7/12	9,201	19,674	5,759	34,634	6,499	26.6	73.4
7/13	7,990	27,711	4,285	39,986	10,476	20.0	80.0
7/14	16,050	36,776	7,337	60,163	12,536	26.7	73.3
7/15	10,973	36,078	6,633	53,684	10,122	20.4	79.6
7/16	11,731	21,453	5,319	38,503	8,248	30.5	69.5
7/17	11,914	21,120	8,042	41,076	10,055	29.00	71.00
7/18	12,759	21,004	8,947	42,710	9,371	29.9	70.1
7/19	9,687	20,239	5,406	35,332	12,365	27.4	72.6
7/20	9,721	21,942	10,213	41,876	12,913	23.2	76.8
7/21	6,207	20,550	10,253	37,010	10,114	16.8	83.2

-continued-

Appendix C1.–Page 2 of 2.

Date	Right bank	Left bank		Total		Percent by bank	
		Nearshore	Offshore	Passage	SE	Right	Left
7/22	5,454	23,409	7,489	36,352	8,692	15.0	85.0
7/23	5,577	21,007	10,245	36,829	4,864	15.1	84.9
7/24	5,138	19,944	10,339	35,421	7,680	14.5	85.5
7/25	4,493	20,265	8,716	33,474	2,615	13.4	86.6
7/26	3,063	16,821	6,248	26,132	4,305	11.7	88.3
7/27	3,489	10,933	3,292	17,714	3,492	19.7	80.3
7/28	2,710	9,208	4,149	16,067	3,354	16.9	83.1
7/29	2,868	9,968	2,828	15,664	3,815	18.3	81.7
7/30	2,046	7,433	1,986	11,465	2,626	17.9	82.2
7/31	2,152	8,008	1,834	11,994	2,413	17.9	82.1
8/01	2,847	9,408	2,707	14,962	1,078	19.0	81.0
8/02	2,151	9,133	1,978	13,262	3,033	16.2	83.8
8/03	3,376	7,906	3,172	14,454	2,965	23.4	76.6
8/04	4,081	20,438	15,451	39,970	3,263	10.2	89.8
8/05	3,816	18,450	15,691	37,957	4,957	10.1	90.0
8/06	2,461	13,535	7,129	23,125	3,050	10.6	89.4
8/07	2,423	10,309	3,581	16,313	3,835	14.9	85.2
8/08	3,022	7,702	2,996	13,720	2,795	22.0	78.0
8/09	4,031	7,714	3,052	14,797	2,729	27.2	72.8
8/10	4,729	11,481	5,022	21,232	2,572	22.3	77.7
8/11	5,007	14,660	5,231	24,898	6,751	20.1	79.9
8/12	5,637	12,051	3,603	21,291	2,293	26.5	73.5
8/13	4,026	8,965	2,619	15,610	3,960	25.8	74.2
8/14	4,352	7,039	1,874	13,265	2,525	32.8	67.2
8/15	6,143	22,734	7,026	35,903	11,906	17.1	82.9
8/16	8,185	48,143	37,012	93,340	9,124	8.8	91.2
8/17	5,880	11,429	15,341	32,650	6,337	18.0	82
8/18	5,584	7,148	6,559	19,291	4,490	29.0	71.0
8/19	5,251	7,597	10,820	23,668	4,619	22.2	77.8
8/20	11,144	89,328	47,238	147,710	27,745	7.6	92.5
8/21	10,652	59,558	73,795	144,005	20,861	7.4	92.6
8/22	8,557	14,201	28,493	51,251	11,335	16.7	83.3
8/23	6,790	10,952	17,627	35,369	6,791	19.2	80.8
8/24	5,253	5,605	8,761	19,619	5,053	26.8	73.2
8/25	4,709	6,444	6,135	17,288	3,791	27.2	72.8
8/26	4,717	5,849	4,341	14,907	5,447	31.6	68.4
8/27	5,320	5,319	6,215	16,854	5,562	31.6	68.4
8/28	5,406	8,037	14,249	27,692	2,758	19.5	80.5
8/29	6,994	11,554	17,477	36,025	4,273	19.4	80.6
8/30	5,593	6,459	8,082	20,134	2,987	27.8	72.2
8/31	5,013	6,822	6,561	18,396	4,445	27.3	72.8
9/01	3,565	7,689	5,895	17,149	3,432	20.8	79.2
9/02	4,282	5,794	4,934	15,010	3,296	28.5	71.5
9/03	4,122	4,877	4,005	13,004	2,356	31.7	68.3
9/04	3,876	3,225	4,470	11,571	2,745	33.5	66.5
9/05	2,846	2,976	3,299	9,121	2,710	31.2	68.8
9/06	2,569	3,194	2,195	7,958	1,774	32.3	67.7
9/07	2,540	3,032	1,626	7,198	1,845	35.3	64.7
Season	865,883	2,259,301	1,313,030	4,438,214	97,505	19.5	80.5

APPENDIX D: DAILY FISH PASSAGE ESTIMATES BY SPECIES

Appendix D1.–Daily fish passage estimates by species, at the Pilot Station sonar site, on the Yukon River, 2014.

	Chinook			Chum					
Date	Large[a]	Small[b]	Total	Summer	Fall	Pink	Coho	Other[c]	Total
6/03	93	0	93	1,206	0	0	0	1,997	3,296
6/04	109	0	109	1,422	0	0	0	2,353	3,884
6/05	1,091	1,432	2,523	12,054	0	0	0	4,844	19,421
6/06	1,581	741	2,322	10,832	0	0	0	6,533	19,687
6/07	311	169	480	8,334	0	0	0	9,331	18,145
6/08	4,478	703	5,181	10,459	0	0	0	5,637	21,277
6/09	7,802	1,214	9,016	17,813	0	0	0	9,330	36,159
6/10	6,499	1,812	8,311	90,021	0	0	0	2,220	100,552
6/11	2,565	1,017	3,582	91,509	0	0	0	5,065	100,156
6/12	1,947	741	2,688	50,826	0	0	0	5,061	58,575
6/13	2,030	225	2,255	28,056	0	0	0	9,210	39,521
6/14	2,474	90	2,564	39,361	0	0	0	1,273	43,198
6/15	4,521	2,758	7,279	14,322	0	0	0	4,231	25,832
6/16	4,611	704	5,315	19,875	0	0	0	1,566	26,756
6/17	5,440	1,268	6,708	66,788	0	0	0	5,571	79,067
6/18	6,253	3,217	9,470	72,418	0	1,062	0	1,739	84,689
6/19	4,542	2,976	7,518	74,247	0	1,202	0	8,190	91,157
6/20	5,248	2,895	8,143	125,868	0	3,477	0	4,196	141,684
6/21	3,132	1,165	4,297	114,943	0	1,463	0	5,004	125,707
6/22	4,387	3,127	7,514	100,987	0	5,763	0	8,701	122,965
6/23	3,550	1,968	5,518	99,929	0	6,855	0	17,473	129,775
6/24	6,991	1,429	8,420	84,223	0	3,050	0	4,875	100,568
6/25	1,279	522	1,801	69,604	0	7,316	0	19,978	98,699
6/26	3,804	173	3,977	45,337	0	8,077	0	31,787	89,178
6/27	3,582	1,132	4,714	46,408	0	4,560	0	14,266	69,948
6/28	595	738	1,333	27,652	0	3,149	0	10,267	42,401
6/29	1,744	567	2,311	50,705	0	6,347	0	8,524	67,887
6/30	1,288	854	2,142	62,574	0	13,905	0	9,702	88,323
7/01	1,825	258	2,083	76,428	0	11,228	0	20,980	110,719
7/02	1,980	0	1,980	55,720	0	13,394	0	3,946	75,040
7/03	803	230	1,033	27,557	0	8,588	0	8,031	45,209
7/04	863	0	863	31,089	0	6,608	0	15,998	54,558
7/05	484	0	484	51,019	0	17,841	0	9,051	78,395
7/06	517	0	517	53,525	0	18,844	0	9,007	81,893
7/07	541	0	541	18,614	0	28,841	0	14,384	62,380
7/08	833	0	833	24,189	0	41,878	0	19,503	86,403
7/09	1,201	0	1,201	21,977	0	47,265	0	34,943	105,386
7/10	814	0	814	14,563	0	29,200	0	21,269	65,846
7/11	134	0	134	10,041	0	15,173	0	12,475	37,823
7/12	228	0	228	10,135	0	13,728	0	10,543	34,634
7/13	185	0	185	12,649	0	12,112	0	15,040	39,986
7/14	263	0	263	20,724	0	18,678	0	20,498	60,163
7/15	94	0	94	19,101	0	14,384	0	20,105	53,684
7/16	56	0	56	13,804	0	10,537	0	14,106	38,503
7/17	144	0	144	12,178	0	12,143	0	16,611	41,076
7/18	0	0	0	13,339	0	12,692	0	16,679	42,710
7/19	92	0	92	0	7,787	7,696	38	19,719	35,332
7/20	92	0	92	0	11,175	8,396	41	22,172	41,876
7/21	0	0	0	0	13,368	11,178	0	12,464	37,010

-continued-

Appendix D1.–Page 2 of 2.

Date	Chinook Large[a]	Chinook Small[b]	Chinook Total	Chum Summer	Chum Fall	Pink	Coho	Other[c]	Total
7/22	337	0	337	0	12,488	9,723	0	13,804	36,352
7/23	0	0	0	0	21,940	7,136	0	7,753	36,829
7/24	0	0	0	0	8,026	11,550	0	15,845	35,421
7/25	0	0	0	0	18,806	13,645	187	836	33,474
7/26	0	0	0	0	11,856	9,620	149	4,507	26,132
7/27	0	0	0	0	7,708	6,856	97	3,053	17,714
7/28	0	0	0	0	5,383	3,509	93	7,082	16,067
7/29	0	0	0	0	3,983	1,885	437	9,359	15,664
7/30	0	0	0	0	3,029	3,434	551	4,451	11,465
7/31	0	0	0	0	3,534	2,024	173	6,263	11,994
8/01	180	0	180	0	4,744	4,347	571	5,120	14,962
8/02	0	0	0	0	1,396	3,086	826	7,954	13,262
8/03	0	0	0	0	2,085	3,248	1,199	7,922	14,454
8/04	0	247	247	0	31,587	3,170	804	4,162	39,970
8/05	0	0	0	0	26,119	0	2,281	9,557	37,957
8/06	0	0	0	0	7,851	776	1,451	13,047	23,125
8/07	0	0	0	0	4,165	1,830	4,126	6,192	16,313
8/08	0	0	0	0	3,015	798	4,508	5,399	13,720
8/09	0	0	0	0	975	294	4,340	9,188	14,797
8/10	0	0	0	0	4,975	0	1,895	14,362	21,232
8/11	0	0	0	0	4,706	38	3,839	16,315	24,898
8/12	0	0	0	0	1,530	0	2,624	17,137	21,291
8/13	0	0	0	0	1,368	0	2,946	11,296	15,610
8/14	0	0	0	0	1,281	0	4,501	7,483	13,265
8/15	0	0	0	0	13,985	0	3,985	17,933	35,903
8/16	0	0	0	0	83,660	0	2,839	6,841	93,340
8/17	0	0	0	0	9,756	0	9,106	13,788	32,650
8/18	0	0	0	0	4,749	0	4,887	9,655	19,291
8/19	0	0	0	0	7,495	0	5,573	10,600	23,668
8/20	0	0	0	0	128,108	0	11,102	8,500	147,710
8/21	0	0	0	0	91,708	0	32,245	20,052	144,005
8/22	0	0	0	0	32,045	0	11,374	7,832	51,251
8/23	0	0	0	0	3,909	0	19,104	12,356	35,369
8/24	0	0	0	0	1,992	0	10,181	7,446	19,619
8/25	0	0	0	0	2,296	0	10,235	4,757	17,288
8/26	0	0	0	0	1,953	0	5,036	7,918	14,907
8/27	0	0	0	0	2,606	0	6,282	7,966	16,854
8/28	0	0	0	0	11,813	0	10,611	5,268	27,692
8/29	0	0	0	0	10,935	0	13,761	11,329	36,025
8/30	0	0	0	0	5,608	0	7,005	7,521	20,134
8/31	0	0	0	0	4,157	0	7,358	6,881	18,396
9/01	0	0	0	0	2,914	0	8,354	5,881	17,149
9/02	0	0	0	0	1,735	0	8,505	4,770	15,010
9/03	0	0	0	0	1,387	0	7,871	3,746	13,004
9/04	0	0	0	0	1,711	0	5,248	4,612	11,571
9/05	0	0	0	0	874	0	3,355	4,892	9,121
9/06	0	0	0	0	348	0	2,682	4,928	7,958
9/07	0	0	0	0	184	0	2,671	4,343	7,198
Total	103,613	34,372	137,985	1,924,425	650,808	513,599	247,047	964,350	4,438,214

[a] Chinook salmon >655 mm.

[b] Chinook salmon ≤655 mm.

[c] Includes sockeye salmon, cisco, whitefish, sheefish, burbot, longnose sucker, Dolly Varden, and northern pike.

APPENDIX E: DIDSON GENERATED COMPONENT AND PROPORTIONS OF DAILY FISH PASSAGE GENERATED BY THE DIDSON

Appendix E1.–DIDSON generated component, by species and day, of the left bank nearshore estimates at the Pilot Station sonar project on the Yukon River, 2014.

	Chinook			Chum					
Date	Large[a]	Small[b]	Total	Summer	Fall	Coho	Pink	Other[c]	Total
6/05	34	18	52	458	0	0	0	223	734
6/06	285	97	383	1,858	0	0	0	986	3,227
6/07	0	0	0	1,217	0	0	0	1,342	2,558
6/08	589	113	702	1,511	0	0	0	784	2,996
6/09	1,087	208	1,295	2,791	0	0	0	1,447	5,533
6/10	684	233	917	10,216	0	0	0	0	11,133
6/11	180	109	289	11,019	0	0	0	687	11,995
6/12	215	45	260	3,960	0	0	0	112	4,332
6/13	143	34	177	1,748	0	0	0	672	2,597
6/14	137	0	137	2,457	0	0	0	0	2,594
6/15	245	185	430	810	0	0	0	254	1,493
6/16	208	27	235	968	0	0	0	108	1,311
6/17	116	78	194	2,236	0	0	0	65	2,494
6/18	258	137	395	3,291	0	0	104	0	3,790
6/19	80	112	192	3,685	0	0	135	59	4,071
6/20	290	234	524	6,717	0	0	237	108	7,586
6/21	153	63	216	7,535	0	0	0	600	8,351
6/22	455	157	612	5,370	0	0	470	1,283	7,736
6/23	169	93	262	4,079	0	0	555	1,563	6,460
6/24	375	155	530	4,779	0	0	438	444	6,191
6/25	56	0	56	3,387	0	0	1,146	3,816	8,404
6/26	366	55	421	2,964	0	0	1,350	4,425	9,162
6/27	296	75	371	4,155	0	0	227	3,642	8,395
6/28	47	169	216	1,709	0	0	561	1,918	4,404
6/29	107	0	107	4,927	0	0	593	1,982	7,610
6/30	73	78	151	5,901	0	0	1,995	1,252	9,298
7/01	129	44	173	5,336	0	0	1,466	3,385	10,360
7/02	189	0	189	7,270	0	0	2,882	416	10,757
7/03	64	73	137	5,087	0	0	1,137	1,293	7,655
7/04	52	0	52	4,020	0	0	1,017	4,381	9,470
7/05	51	0	51	6,138	0	0	3,124	1,126	10,438
7/06	79	0	79	9,408	0	0	4,788	1,725	16,000
7/07	111	0	111	2,257	0	0	4,975	2,298	9,642
7/08	191	0	191	3,882	0	0	8,558	3,953	16,585
7/09	144	0	144	3,057	0	0	8,432	6,375	18,008
7/10	70	0	70	1,493	0	0	4,120	3,114	8,798
7/11	0	0	0	1,028	0	0	1,830	1,673	4,530
7/12	0	0	0	800	0	0	1,425	1,303	3,528
7/13	22	0	22	861	0	0	1,313	2,326	4,523
7/14	30	0	30	1,133	0	0	1,728	3,061	5,952
7/15	22	0	22	2,531	0	0	2,321	3,701	8,575
7/16	6	0	6	627	0	0	574	916	2,123
7/17	0	0	0	946	0	0	1,065	3,465	5,476
7/18	0	0	0	606	0	0	2,962	2,487	6,055
7/19	0	0	0	0	383	9	680	3,885	4,957
7/20	0	0	0	0	378	9	671	3,834	4,892
7/21	0	0	0	0	1,019	0	844	2,675	4,537

-continued-

Appendix E1.–Page 2 of 2.

Date	Chinook			Chum		Coho	Pink	Other[c]	Total
	Large[a]	Small[b]	Total	Summer	Fall				
7/22	61	0	61	0	1,701	0	2,268	3,599	7,629
7/23	0	0	0	0	4,373	0	1,847	1,872	8,091
7/24	0	0	0	0	297	0	1,879	1,548	3,724
7/25	0	0	0	0	1,271	27	1,550	105	2,953
7/26	0	0	0	0	948	28	1,474	658	3,107
7/27	0	0	0	0	757	22	1,178	526	2,483
7/28	0	0	0	0	201	0	556	1,306	2,062
7/29	0	0	0	0	125	0	212	1,309	1,646
7/30	0	0	0	0	232	93	391	540	1,255
7/31	0	0	0	0	284	0	227	863	1,375
8/01	0	0	0	0	535	27	908	969	2,438
8/02	0	0	0	0	46	36	530	1,511	2,124
8/03	0	0	0	0	40	31	453	1,292	1,816
8/04	0	0	0	0	2,406	64	422	422	3,314
8/05	0	0	0	0	1,744	205	0	802	2,751
8/06	0	0	0	0	454	46	152	2,738	3,390
8/07	0	0	0	0	1,104	1,029	713	1,823	4,669
8/08	0	0	0	0	537	999	199	1,215	2,950
8/09	0	0	0	0	134	432	101	1,983	2,649
8/10	0	0	0	0	153	58	0	2,875	3,086
8/11	0	0	0	0	343	787	0	4,216	5,345
8/12	0	0	0	0	70	180	0	4,047	4,297
8/13	0	0	0	0	179	298	0	2,471	2,948
8/14	0	0	0	0	151	776	0	1,591	2,517
8/15	0	0	0	0	917	299	0	1,689	2,904
8/16	0	0	0	0	4,218	149	0	170	4,537
8/17	0	0	0	0	464	443	0	1,577	2,485
8/18	0	0	0	0	247	236	0	840	1,324
8/19	0	0	0	0	73	179	0	1,280	1,532
8/20	0	0	0	0	6,605	242	0	378	7,225
8/21	0	0	0	0	3,484	1,629	0	1,588	6,702
8/22	0	0	0	0	1,932	903	0	881	3,716
8/23	0	0	0	0	189	643	0	2,333	3,165
8/24	0	0	0	0	59	201	0	729	989
8/25	0	0	0	0	321	1,593	0	386	2,300
8/26	0	0	0	0	69	382	0	1,388	1,840
8/27	0	0	0	0	78	432	0	1,568	2,079
8/28	0	0	0	0	460	355	0	708	1,523
8/29	0	0	0	0	420	666	0	1,139	2,225
8/30	0	0	0	0	381	604	0	1,033	2,018
8/31	0	0	0	0	625	542	0	1,061	2,228
9/01	0	0	0	0	216	648	0	432	1,296
9/02	0	0	0	0	73	1,081	0	415	1,568
9/03	0	0	0	0	50	556	0	734	1,340
9/04	0	0	0	0	10	55	0	399	464
9/05	0	0	0	0	83	181	0	759	1,023
9/06	0	0	0	0	39	211	0	856	1,106
9/07	0	0	0	0	0	407	0	952	1,360
Total	7,869	2,592	10,461	156,228	40,878	17,793	78,783	148,740	452,884

[a] Chinook salmon >655 mm.

[b] Chinook salmon ≤655 mm.

[c] Includes sockeye salmon, cisco, whitefish, sheefish, burbot, longnose sucker, Dolly Varden, and northern pike.

Appendix E2.–Species proportions, of total daily passage (both banks combined), generated by the DIDSON, at the Pilot Station sonar project on the Yukon River, 2014.

	Chinook			Chum					
Date	Large [a]	Small [b]	Total	Summer	Fall	Coho	Pink	Other [c]	Total
6/05	0.03	0.01	0.02	0.04	0.00	0.00	0.00	0.05	0.04
6/06	0.18	0.13	0.00	0.15	0.00	0.00	0.00	0.15	0.16
6/07	0.00	0.00	0.14	0.14	0.00	0.00	0.00	0.14	0.14
6/08	0.13	0.16	0.14	0.16	0.00	0.00	0.00	0.14	0.14
6/09	0.14	0.17	0.11	0.11	0.00	0.00	0.00	0.16	0.15
6/10	0.11	0.13	0.08	0.12	0.00	0.00	0.00	0.00	0.11
6/11	0.07	0.11	0.10	0.08	0.00	0.00	0.00	0.14	0.12
6/12	0.11	0.06	0.08	0.06	0.00	0.00	0.00	0.02	0.07
6/13	0.07	0.15	0.05	0.06	0.00	0.00	0.00	0.07	0.07
6/14	0.06	0.00	0.06	0.06	0.00	0.00	0.00	0.00	0.06
6/15	0.05	0.07	0.04	0.05	0.00	0.00	0.00	0.06	0.06
6/16	0.05	0.04	0.03	0.03	0.00	0.00	0.00	0.07	0.05
6/17	0.02	0.06	0.04	0.05	0.00	0.00	0.00	0.01	0.03
6/18	0.04	0.04	0.03	0.05	0.00	0.00	0.10	0.00	0.04
6/19	0.02	0.04	0.06	0.05	0.00	0.00	0.11	0.01	0.04
6/20	0.06	0.08	0.05	0.07	0.00	0.00	0.07	0.03	0.05
6/21	0.05	0.05	0.08	0.05	0.00	0.00	0.00	0.12	0.07
6/22	0.10	0.05	0.05	0.04	0.00	0.00	0.08	0.15	0.06
6/23	0.05	0.05	0.06	0.06	0.00	0.00	0.08	0.09	0.05
6/24	0.05	0.11	0.03	0.05	0.00	0.00	0.14	0.09	0.06
6/25	0.04	0.00	0.11	0.07	0.00	0.00	0.16	0.19	0.09
6/26	0.10	0.32	0.08	0.09	0.00	0.00	0.17	0.14	0.10
6/27	0.08	0.07	0.16	0.06	0.00	0.00	0.05	0.26	0.12
6/28	0.08	0.23	0.05	0.10	0.00	0.00	0.18	0.19	0.10
6/29	0.06	0.00	0.07	0.09	0.00	0.00	0.09	0.23	0.11
6/30	0.06	0.09	0.08	0.07	0.00	0.00	0.14	0.13	0.11
7/01	0.07	0.17	0.10	0.13	0.00	0.00	0.13	0.16	0.09
7/02	0.10	0.00	0.13	0.18	0.00	0.00	0.22	0.11	0.14
7/03	0.08	0.32	0.06	0.13	0.00	0.00	0.13	0.16	0.17
7/04	0.06	0.00	0.11	0.12	0.00	0.00	0.15	0.27	0.17
7/05	0.11	0.00	0.00	0.18	0.00	0.00	0.18	0.12	0.13
7/06	0.15	0.00	0.21	0.12	0.00	0.00	0.25	0.19	0.20
7/07	0.21	0.00	0.23	0.16	0.00	0.00	0.17	0.16	0.15
7/08	0.23	0.00	0.00	0.14	0.00	0.00	0.20	0.20	0.19
7/09	0.12	0.00	0.09	0.00	0.00	0.00	0.18	0.18	0.17
7/10	0.09	0.00	0.00	0.00	0.00	0.00	0.14	0.15	0.13
7/11	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.13	0.12
7/12	0.00	0.00	0.12	0.00	0.00	0.00	0.10	0.12	0.10
7/13	0.12	0.00	0.00	0.00	0.00	0.00	0.11	0.15	0.11
7/14	0.11	0.00	0.00	0.00	0.00	0.00	0.09	0.15	0.10
7/15	0.23	0.00	0.00	0.00	0.00	0.00	0.16	0.18	0.16
7/16	0.11	0.00	0.00	0.00	0.00	0.00	0.05	0.06	0.06
7/17	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.21	0.13
7/18	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.15	0.14
7/19	0.00	0.00	0.00	0.00	0.05	0.24	0.09	0.20	0.14
7/20	0.00	0.00	0.00	0.00	0.03	0.22	0.08	0.17	0.12
7/21	0.00	0.00	0.00	0.00	0.08	0.00	0.08	0.21	0.12

-continued-

Appendix E2.–Page 2 of 2.

	Chinook			Chum					
Date	Large [a]	Small [b]	Total	Summer	Fall	Coho	Pink	Other [c]	Total
7/22	0.18	0.00	0.18	0.00	0.14	0.00	0.23	0.26	0.55
7/23	0.00	0.00	0.00	0.00	0.20	0.00	0.26	0.24	1.04
7/24	0.00	0.00	0.00	0.00	0.04	0.00	0.16	0.10	0.24
7/25	0.00	0.00	0.00	0.00	0.07	0.14	0.11	0.13	3.53
7/26	0.00	0.00	0.00	0.00	0.08	0.19	0.15	0.15	0.69
7/27	0.00	0.00	0.00	0.00	0.10	0.23	0.17	0.17	0.81
7/28	0.00	0.00	0.00	0.00	0.04	0.00	0.16	0.18	0.29
7/29	0.00	0.00	0.00	0.00	0.03	0.00	0.11	0.14	0.18
7/30	0.00	0.00	0.00	0.00	0.08	0.17	0.11	0.12	0.28
7/31	0.00	0.00	0.00	0.00	0.08	0.00	0.11	0.14	0.22
8/01	0.00	0.00	0.00	0.00	0.11	0.05	0.21	0.19	0.48
8/02	0.00	0.00	0.00	0.00	0.03	0.04	0.17	0.19	0.27
8/03	0.00	0.00	0.00	0.00	0.02	0.03	0.14	0.16	0.23
8/04	0.00	0.00	0.00	0.00	0.08	0.08	0.13	0.10	0.80
8/05	0.00	0.00	0.00	0.00	0.07	0.09	0.00	0.08	0.29
8/06	0.00	0.00	0.00	0.00	0.06	0.03	0.20	0.21	0.26
8/07	0.00	0.00	0.00	0.00	0.27	0.25	0.39	0.29	0.75
8/08	0.00	0.00	0.00	0.00	0.18	0.22	0.25	0.23	0.55
8/09	0.00	0.00	0.00	0.00	0.14	0.10	0.34	0.22	0.29
8/10	0.00	0.00	0.00	0.00	0.03	0.03	0.00	0.20	0.21
8/11	0.00	0.00	0.00	0.00	0.07	0.21	0.00	0.26	0.33
8/12	0.00	0.00	0.00	0.00	0.05	0.07	0.00	0.24	0.25
8/13	0.00	0.00	0.00	0.00	0.13	0.10	0.00	0.22	0.26
8/14	0.00	0.00	0.00	0.00	0.12	0.17	0.00	0.21	0.34
8/15	0.00	0.00	0.00	0.00	0.07	0.08	0.00	0.09	0.16
8/16	0.00	0.00	0.00	0.00	0.05	0.05	0.00	0.02	0.66
8/17	0.00	0.00	0.00	0.00	0.05	0.05	0.00	0.11	0.18
8/18	0.00	0.00	0.00	0.00	0.05	0.05	0.00	0.09	0.14
8/19	0.00	0.00	0.00	0.00	0.01	0.03	0.00	0.12	0.14
8/20	0.00	0.00	0.00	0.00	0.05	0.02	0.00	0.04	0.85
8/21	0.00	0.00	0.00	0.00	0.04	0.05	0.00	0.08	0.33
8/22	0.00	0.00	0.00	0.00	0.06	0.08	0.00	0.11	0.47
8/23	0.00	0.00	0.00	0.00	0.05	0.03	0.00	0.19	0.26
8/24	0.00	0.00	0.00	0.00	0.03	0.02	0.00	0.10	0.13
8/25	0.00	0.00	0.00	0.00	0.14	0.16	0.00	0.08	0.48
8/26	0.00	0.00	0.00	0.00	0.04	0.08	0.00	0.18	0.23
8/27	0.00	0.00	0.00	0.00	0.03	0.07	0.00	0.20	0.26
8/28	0.00	0.00	0.00	0.00	0.04	0.03	0.00	0.13	0.29
8/29	0.00	0.00	0.00	0.00	0.04	0.05	0.00	0.10	0.20
8/30	0.00	0.00	0.00	0.00	0.07	0.09	0.00	0.14	0.27
8/31	0.00	0.00	0.00	0.00	0.15	0.07	0.00	0.15	0.32
9/01	0.00	0.00	0.00	0.00	0.07	0.08	0.00	0.07	0.22
9/02	0.00	0.00	0.00	0.00	0.04	0.13	0.00	0.09	0.33
9/03	0.00	0.00	0.00	0.00	0.04	0.07	0.00	0.20	0.36
9/04	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.09	0.10
9/05	0.00	0.00	0.00	0.00	0.09	0.05	0.00	0.16	0.21
9/06	0.00	0.00	0.00	0.00	0.11	0.08	0.00	0.17	0.22
9/07	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.22	0.31
Total	0.08	0.08	0.08	0.08	0.06	0.07	0.15	0.15	0.10

[a] Chinook salmon >655 mm.

[b] Chinook salmon ≤655 mm.

[c] Includes sockeye salmon, cisco, whitefish, sheefish, burbot, longnose sucker, Dolly Varden, and northern pike.

APPENDIX F: DAILY CUMULATIVE FISH PASSAGE ESTIMATES, PROPORTIONS, AND TIMING BY SPECIES

Appendix F1.–Daily cumulative fish passage proportions and timing by species, at the Pilot Station sonar project on the Yukon River, 2014.

	Chinook			Chum					
Date	Large [a]	Small [b]	Total	Summer	Fall	Pink	Coho	Other [c]	Total
6/03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6/04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6/05	0.01	0.04	0.02	0.01	0.00	0.00	0.00	0.01	0.01
6/06	0.03	0.06	0.04	0.01	0.00	0.00	0.00	0.02	0.01
6/07	0.03	0.07	0.04	0.02	0.00	0.00	0.00	0.03	0.01
6/08	0.07	0.09	0.08	0.02	0.00	0.00	0.00	0.03	0.02
6/09	0.15	0.12	0.14	0.03	0.00	0.00	0.00	0.04	0.03
6/10	0.21	0.18	0.20	0.08	0.00	0.00	0.00	0.04	0.05
6/11	0.24	0.21	0.23	0.13	0.00	0.00	0.00	0.05	0.07
6/12	**0.26**	0.23	**0.25**	0.15	0.00	0.00	0.00	0.05	0.09
6/13	0.28	0.23	0.26	0.17	0.00	0.00	0.00	0.06	0.09
6/14	0.30	0.24	0.28	0.19	0.00	0.00	0.00	0.07	0.10
6/15	0.34	**0.32**	0.34	0.20	0.00	0.00	0.00	0.07	0.11
6/16	0.39	0.34	0.37	0.21	0.00	0.00	0.00	0.07	0.12
6/17	0.44	0.37	0.42	0.24	0.00	0.00	0.00	0.08	0.13
6/18	**0.50**	0.47	0.49	**0.28**	0.00	0.00	0.00	0.08	0.15
6/19	0.54	**0.55**	**0.55**	0.32	0.00	0.00	0.00	0.09	0.17
6/20	0.59	0.64	0.61	0.38	0.00	0.01	0.00	0.09	0.21
6/21	0.62	0.67	0.64	0.44	0.00	0.01	0.00	0.10	0.23
6/22	0.67	**0.76**	0.69	0.49	0.00	0.03	0.00	0.11	**0.26**
6/23	0.70	0.82	0.73	**0.55**	0.00	0.04	0.00	0.12	0.29
6/24	**0.77**	0.86	**0.79**	0.59	0.00	0.04	0.00	0.13	0.31
6/25	0.78	0.88	0.81	0.63	0.00	0.06	0.00	0.15	0.34
6/26	0.82	0.88	0.83	0.65	0.00	0.07	0.00	0.18	0.36
6/27	0.85	0.92	0.87	0.67	0.00	0.08	0.00	0.20	0.37
6/28	0.86	0.94	0.88	0.69	0.00	0.09	0.00	0.21	0.38
6/29	0.87	0.95	0.89	0.71	0.00	0.10	0.00	0.22	0.40
6/30	0.89	0.98	0.91	**0.75**	0.00	0.13	0.00	0.23	0.42
7/01	0.91	0.99	0.93	0.79	0.00	0.15	0.00	**0.25**	0.44
7/02	0.92	0.99	0.94	0.82	0.00	0.18	0.00	0.25	0.46
7/03	0.93	0.99	0.95	0.83	0.00	0.19	0.00	0.26	0.47
7/04	0.94	0.99	0.95	0.85	0.00	0.21	0.00	0.28	0.48
7/05	0.94	0.99	0.96	0.87	0.00	0.24	0.00	0.29	**0.50**
7/06	0.95	0.99	0.96	0.90	0.00	**0.28**	0.00	0.30	0.52
7/07	0.96	0.99	0.96	0.91	0.00	0.33	0.00	0.31	0.53
7/08	0.96	0.99	0.97	0.92	0.00	0.42	0.00	0.33	0.55
7/09	0.97	0.99	0.98	0.93	0.00	**0.51**	0.00	0.37	0.57
7/10	0.98	0.99	0.99	0.94	0.00	0.56	0.00	0.39	0.59
7/11	0.98	0.99	0.99	0.95	0.00	0.59	0.00	0.40	0.60
7/12	0.99	0.99	0.99	0.95	0.00	0.62	0.00	0.41	0.61
7/13	0.99	0.99	0.99	0.96	0.00	0.64	0.00	0.43	0.61
7/14	0.99	0.99	0.99	0.97	0.00	0.68	0.00	0.45	0.63
7/15	0.99	0.99	0.99	0.98	0.00	0.71	0.00	0.47	0.64
7/16	0.99	0.99	0.99	0.99	0.00	0.73	0.00	0.49	0.65
7/17	0.99	0.99	0.99	0.99	0.00	**0.75**	0.00	**0.50**	0.66
7/18	0.99	0.99	0.99	1.00	0.00	0.78	0.00	0.52	0.67
7/19	0.99	0.99	0.99	1.00	0.01	0.79	0.00	0.54	0.68
7/20	1.00	0.99	0.99	1.00	0.03	0.81	0.00	0.56	0.68
7/21	1.00	0.99	0.99	1.00	0.05	0.83	0.00	0.58	0.69

-continued-

Appendix F1.–Page 2 of 2.

Date	Chinook			Chum		Pink	Coho	Other [c]	Total
	Large [a]	Small [b]	Total	Summer	Fall				
7/22	1.00	0.99	1.00	1.00	0.07	0.85	0.00	0.59	0.70
7/23	1.00	0.99	1.00	1.00	0.10	0.86	0.00	0.60	0.71
7/24	1.00	0.99	1.00	1.00	0.11	0.89	0.00	0.62	0.72
7/25	1.00	0.99	1.00	1.00	0.14	0.91	0.00	0.62	0.73
7/26	1.00	0.99	1.00	1.00	0.16	0.93	0.00	0.62	0.73
7/27	1.00	0.99	1.00	1.00	0.17	0.94	0.00	0.62	0.74
7/28	1.00	0.99	1.00	1.00	0.18	0.95	0.00	0.63	0.74
7/29	1.00	0.99	1.00	1.00	0.19	0.96	0.00	0.64	0.74
7/30	1.00	0.99	1.00	1.00	0.19	0.96	0.01	0.65	0.74
7/31	1.00	0.99	1.00	1.00	0.20	0.97	0.01	0.65	**0.75**
8/01	1.00	0.99	1.00	1.00	0.21	0.97	0.01	0.66	0.75
8/02	1.00	0.99	1.00	1.00	0.21	0.98	0.01	0.67	0.75
8/03	1.00	0.99	1.00	1.00	0.21	0.99	0.02	0.67	0.76
8/04	1.00	1.00	1.00	1.00	**0.26**	0.99	0.02	0.68	0.77
8/05	1.00	1.00	1.00	1.00	0.30	0.99	0.03	0.69	0.77
8/06	1.00	1.00	1.00	1.00	0.31	0.99	0.04	0.70	0.78
8/07	1.00	1.00	1.00	1.00	0.32	1.00	0.05	0.71	0.78
8/08	1.00	1.00	1.00	1.00	0.32	1.00	0.07	0.71	0.79
8/09	1.00	1.00	1.00	1.00	0.32	1.00	0.09	0.72	0.79
8/10	1.00	1.00	1.00	1.00	0.33	1.00	0.10	0.74	0.79
8/11	1.00	1.00	1.00	1.00	0.34	1.00	0.11	**0.76**	0.80
8/12	1.00	1.00	1.00	1.00	0.34	1.00	0.12	0.77	0.81
8/13	1.00	1.00	1.00	1.00	0.34	1.00	0.13	0.79	0.81
8/14	1.00	1.00	1.00	1.00	0.35	1.00	0.15	0.79	0.81
8/15	1.00	1.00	1.00	1.00	0.37	1.00	0.17	0.81	0.82
8/16	1.00	1.00	1.00	1.00	**0.50**	1.00	0.18	0.82	0.84
8/17	1.00	1.00	1.00	1.00	0.51	1.00	0.22	0.83	0.85
8/18	1.00	1.00	1.00	1.00	0.52	1.00	0.24	0.84	0.85
8/19	1.00	1.00	1.00	1.00	0.53	1.00	**0.26**	0.85	0.86
8/20	1.00	1.00	1.00	1.00	0.73	1.00	0.30	0.86	0.89
8/21	1.00	1.00	1.00	1.00	**0.87**	1.00	0.43	0.88	0.92
8/22	1.00	1.00	1.00	1.00	0.92	1.00	0.48	0.89	0.94
8/23	1.00	1.00	1.00	1.00	0.92	1.00	**0.56**	0.90	0.94
8/24	1.00	1.00	1.00	1.00	0.93	1.00	0.60	0.91	0.95
8/25	1.00	1.00	1.00	1.00	0.93	1.00	0.64	0.92	0.95
8/26	1.00	1.00	1.00	1.00	0.93	1.00	0.66	0.93	0.95
8/27	1.00	1.00	1.00	1.00	0.94	1.00	0.69	0.93	0.96
8/28	1.00	1.00	1.00	1.00	0.95	1.00	0.73	0.94	0.96
8/29	1.00	1.00	1.00	1.00	0.97	1.00	**0.79**	0.95	0.97
8/30	1.00	1.00	1.00	1.00	0.98	1.00	0.81	0.96	0.98
8/31	1.00	1.00	1.00	1.00	0.99	1.00	0.84	0.97	0.98
9/01	1.00	1.00	1.00	1.00	0.99	1.00	0.88	0.97	0.99
9/02	1.00	1.00	1.00	1.00	0.99	1.00	0.91	0.98	0.99
9/03	1.00	1.00	1.00	1.00	1.00	1.00	0.94	0.98	0.99
9/04	1.00	1.00	1.00	1.00	1.00	1.00	0.96	0.99	0.99
9/05	1.00	1.00	1.00	1.00	1.00	1.00	0.98	0.99	1.00
9/06	1.00	1.00	1.00	1.00	1.00	1.00	0.99	1.00	1.00
9/07	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Note: The 25th , 50th , and 75th percentiles are in bold.

[a] Chinook salmon >655 mm.

[b] Chinook salmon ≤655 mm.

[c] Includes sockeye salmon, cisco, whitefish, sheefish, burbot, longnose sucker, Dolly Varden, and northern pike.

Appendix F2.–Daily cumulative fish passage estimates, by species, at the Pilot Station sonar project on the Yukon River, 2014.

	Chinook			Chum					
Date	Large [a]	Small [b]	Total	Summer	Fall	Coho	Pink	Other [c]	Total
6/03	93	0	93	1,206	0	0	0	1,997	3,296
6/04	202	0	202	2,628	0	0	0	4,350	7,180
6/05	1,293	1,432	2,725	14,682	0	0	0	9,194	26,601
6/06	2,874	2,173	5,047	25,514	0	0	0	15,727	46,288
6/07	3,185	2,342	5,527	33,848	0	0	0	25,058	64,433
6/08	7,663	3,045	10,708	44,307	0	0	0	30,695	85,710
6/09	15,465	4,259	19,724	62,120	0	0	0	40,025	121,869
6/10	21,964	6,071	28,035	152,141	0	0	0	42,245	222,421
6/11	24,529	7,088	31,617	243,650	0	0	0	47,310	322,577
6/12	26,476	7,829	34,305	294,476	0	0	0	52,371	381,152
6/13	28,506	8,054	36,560	322,532	0	0	0	61,581	420,673
6/14	30,980	8,144	39,124	361,893	0	0	0	62,854	463,871
6/15	35,501	10,902	46,403	376,215	0	0	0	67,085	489,703
6/16	40,112	11,606	51,718	396,090	0	0	0	68,651	516,459
6/17	45,552	12,874	58,426	462,878	0	0	0	74,222	595,526
6/18	51,805	16,091	67,896	535,296	0	0	1,062	75,961	680,215
6/19	56,347	19,067	75,414	609,543	0	0	2,264	84,151	771,372
6/20	61,595	21,962	83,557	735,411	0	0	5,741	88,347	913,056
6/21	64,727	23,127	87,854	850,354	0	0	7,204	93,351	1,038,763
6/22	69,114	26,254	95,368	951,341	0	0	12,967	102,052	1,161,728
6/23	72,664	28,222	100,886	1,051,270	0	0	19,822	119,525	1,291,503
6/24	79,655	29,651	109,306	1,135,493	0	0	22,872	124,400	1,392,071
6/25	80,934	30,173	111,107	1,205,097	0	0	30,188	144,378	1,490,770
6/26	84,738	30,346	115,084	1,250,434	0	0	38,265	176,165	1,579,948
6/27	88,320	31,478	119,798	1,296,842	0	0	42,825	190,431	1,649,896
6/28	88,915	32,216	121,131	1,324,494	0	0	45,974	200,698	1,692,297
6/29	90,659	32,783	123,442	1,375,199	0	0	52,321	209,222	1,760,184
6/30	91,947	33,637	125,584	1,437,773	0	0	66,226	218,924	1,848,507
7/01	93,772	33,895	127,667	1,514,201	0	0	77,454	239,904	1,959,226
7/02	95,752	33,895	129,647	1,569,921	0	0	90,848	243,850	2,034,266
7/03	96,555	34,125	130,680	1,597,478	0	0	99,436	251,881	2,079,475
7/04	97,418	34,125	131,543	1,628,567	0	0	106,044	267,879	2,134,033
7/05	97,902	34,125	132,027	1,679,586	0	0	123,885	276,930	2,212,428
7/06	98,419	34,125	132,544	1,733,111	0	0	142,729	285,937	2,294,321
7/07	98,960	34,125	133,085	1,751,725	0	0	171,570	300,321	2,356,701
7/08	99,793	34,125	133,918	1,775,914	0	0	213,448	319,824	2,443,104
7/09	100,994	34,125	135,119	1,797,891	0	0	260,713	354,767	2,548,490
7/10	101,808	34,125	135,933	1,812,454	0	0	289,913	376,036	2,614,336
7/11	101,942	34,125	136,067	1,822,495	0	0	305,086	388,511	2,652,159
7/12	102,170	34,125	136,295	1,832,630	0	0	318,814	399,054	2,686,793
7/13	102,355	34,125	136,480	1,845,279	0	0	330,926	414,094	2,726,779
7/14	102,618	34,125	136,743	1,866,003	0	0	349,604	434,592	2,786,942
7/15	102,712	34,125	136,837	1,885,104	0	0	363,988	454,697	2,840,626
7/16	102,768	34,125	136,893	1,898,908	0	0	374,525	468,803	2,879,129
7/17	102,912	34,125	137,037	1,911,086	0	0	386,668	485,414	2,920,205
7/18	102,912	34,125	137,037	1,924,425	0	38	399,360	502,093	2,962,953
7/19	103,004	34,125	137,129	1,924,425	7,787	79	407,056	521,812	2,998,288
7/20	103,096	34,125	137,221	1,924,425	18,962	79	415,452	543,984	3,040,123
7/21	103,096	34,125	137,221	1,924,425	32,330	79	426,630	556,448	3,077,133

-continued-

Appendix F2.–Page 2 of 2.

Date	Chinook			Chum		Coho	Pink	Other [c]	Total
	Large [a]	Small [b]	Total	Summer	Fall				
7/22	103,433	34,125	137,558	1,924,425	44,818	79	436,353	570,252	3,113,485
7/23	103,433	34,125	137,558	1,924,425	66,758	79	443,489	578,005	3,150,314
7/24	103,433	34,125	137,558	1,924,425	74,784	79	455,039	593,850	3,185,735
7/25	103,433	34,125	137,558	1,924,425	93,590	266	468,684	594,686	3,219,209
7/26	103,433	34,125	137,558	1,924,425	105,446	415	478,304	599,193	3,245,341
7/27	103,433	34,125	137,558	1,924,425	113,154	512	485,160	602,246	3,263,055
7/28	103,433	34,125	137,558	1,924,425	118,537	605	488,669	609,328	3,279,122
7/29	103,433	34,125	137,558	1,924,425	122,520	1,042	490,554	618,687	3,294,786
7/30	103,433	34,125	137,558	1,924,425	125,549	1,593	493,988	623,138	3,306,251
7/31	103,433	34,125	137,558	1,924,425	129,083	1,766	496,012	629,401	3,318,245
8/01	103,613	34,125	137,738	1,924,425	133,827	2,337	500,359	634,521	3,333,207
8/02	103,613	34,125	137,738	1,924,425	135,223	3,163	503,445	642,475	3,346,469
8/03	103,613	34,125	137,738	1,924,425	137,308	4,362	506,693	650,397	3,360,923
8/04	103,613	34,372	137,985	1,924,425	168,895	5,166	509,863	654,559	3,400,893
8/05	103,613	34,372	137,985	1,924,425	195,014	7,447	509,863	664,116	3,438,850
8/06	103,613	34,372	137,985	1,924,425	202,865	8,898	510,639	677,163	3,461,975
8/07	103,613	34,372	137,985	1,924,425	207,030	13,024	512,469	683,355	3,478,288
8/08	103,613	34,372	137,985	1,924,425	210,045	17,532	513,267	688,754	3,492,008
8/09	103,613	34,372	137,985	1,924,425	211,020	21,872	513,561	697,942	3,506,805
8/10	103,613	34,372	137,985	1,924,425	215,995	23,767	513,561	712,304	3,528,037
8/11	103,613	34,372	137,985	1,924,425	220,701	27,606	513,599	728,619	3,552,935
8/12	103,613	34,372	137,985	1,924,425	222,231	30,230	513,599	745,756	3,574,226
8/13	103,613	34,372	137,985	1,924,425	223,599	33,176	513,599	757,052	3,589,836
8/14	103,613	34,372	137,985	1,924,425	224,880	37,677	513,599	764,535	3,603,101
8/15	103,613	34,372	137,985	1,924,425	238,865	41,662	513,599	782,468	3,639,004
8/16	103,613	34,372	137,985	1,924,425	322,525	44,501	513,599	789,309	3,732,344
8/17	103,613	34,372	137,985	1,924,425	332,281	53,607	513,599	803,097	3,764,994
8/18	103,613	34,372	137,985	1,924,425	337,030	58,494	513,599	812,752	3,784,285
8/19	103,613	34,372	137,985	1,924,425	344,525	64,067	513,599	823,352	3,807,953
8/20	103,613	34,372	137,985	1,924,425	472,633	75,169	513,599	831,852	3,955,663
8/21	103,613	34,372	137,985	1,924,425	564,341	107,414	513,599	851,904	4,099,668
8/22	103,613	34,372	137,985	1,924,425	596,386	118,788	513,599	859,736	4,150,919
8/23	103,613	34,372	137,985	1,924,425	600,295	137,892	513,599	872,092	4,186,288
8/24	103,613	34,372	137,985	1,924,425	602,287	148,073	513,599	879,538	4,205,907
8/25	103,613	34,372	137,985	1,924,425	604,583	158,308	513,599	884,295	4,223,195
8/26	103,613	34,372	137,985	1,924,425	606,536	163,344	513,599	892,213	4,238,102
8/27	103,613	34,372	137,985	1,924,425	609,142	169,626	513,599	900,179	4,254,956
8/28	103,613	34,372	137,985	1,924,425	620,955	180,237	513,599	905,447	4,282,648
8/29	103,613	34,372	137,985	1,924,425	631,890	193,998	513,599	916,776	4,318,673
8/30	103,613	34,372	137,985	1,924,425	637,498	201,003	513,599	924,297	4,338,807
8/31	103,613	34,372	137,985	1,924,425	641,655	208,361	513,599	931,178	4,357,203
9/01	103,613	34,372	137,985	1,924,425	644,569	216,715	513,599	937,059	4,374,352
9/02	103,613	34,372	137,985	1,924,425	646,304	225,220	513,599	941,829	4,389,362
9/03	103,613	34,372	137,985	1,924,425	647,691	233,091	513,599	945,575	4,402,366
9/04	103,613	34,372	137,985	1,924,425	649,402	238,339	513,599	950,187	4,413,937
9/05	103,613	34,372	137,985	1,924,425	650,276	241,694	513,599	955,079	4,423,058
9/06	103,613	34,372	137,985	1,924,425	650,624	244,376	513,599	960,007	4,431,016
9/07	103,613	34,372	137,985	1,924,425	650,808	247,047	513,599	964,350	4,438,214

[a] Chinook salmon >655 mm.

[b] Chinook salmon ≤655 mm.

[c] Includes sockeye salmon, cisco, whitefish, sheefish, burbot, longnose sucker, Dolly Varden, and northern pike.

APPENDIX G: PILOT STATION SONAR FISH PASSAGE ESTIMATES BY SPECIES, 1995–2014

Appendix G1.–Pilot Station sonar project passage estimates on the Yukon River, 1995–2014.

	Chinook			Chum						
Year [a]	Large [b]	Small [c]	Total	Summer	Fall [d]	Total	Coho [d]	Pink	Other [e]	Total
2014	103,613	34,372	137,985	1,924,425	650,808	2,575,233	247,047	513,599	964,350	4,438,214
2013	105,433	11,726	117,159	2,747,218	716,727	3,463,945	84,795	4,624	1,029,900	4,700,423
2012	90,936	15,790	106,726	2,130,404	682,510	2,812,914	106,782	352,518	678,382	4,057,322
2011	87,090	19,937	107,027	1,778,870	698,762	2,477,632	118,453	5,934	637,062	3,346,108
2010	95,913	17,497	113,410	1,327,581	350,981	1,678,562	142,149	651,128	761,800	3,347,049
2009 [f]	92,648	30,342	122,990	1,285,437	240,449	1,525,866	205,278	16,380	677,860	2,548,394
2008	106,708	23,935	130,643	1,665,667	615,127	2,280,794	135,570	558,050	585,303	3,690,360
2007	90,184	35,369	125,553	1,726,885	684,011	2,410,896	173,289	71,699	1,085,316	3,866,753
2006	145,553	23,850	169,403	3,767,044	790,563	4,557,607	131,919	115,624	875,899	5,850,452
2005 [g]	142,007	17,434	159,441	2,439,616	1,813,589	4,253,205	184,718	37,932	593,248	5,228,544
2004	110,236	46,370	156,606	1,357,826	594,060	1,951,886	188,350	243,375	637,257	3,177,474
2003	245,037	23,500	268,537	1,168,518	889,778	2,058,296	269,081	4,656	502,878	3,103,448
2002	92,584	30,629	123,213	1,088,463	326,858	1,415,321	122,566	64,891	557,779	2,283,770
2001 [f]	85,511	13,892	99,403	441,450	376,182	817,632	137,769	665	353,431	1,408,900
2000	39,233	5,195	44,428	456,271	247,935	704,206	175,421	35,501	361,222	1,320,778
1999	127,809	16,914	144,723	973,708	379,493	1,353,201	62,521	1,801	465,515	2,027,761
1998	71,177	16,675	87,852	826,385	372,927	1,199,312	136,906	66,751	277,566	1,768,387
1997 [h]	118,121	77,526	195,647	1,415,641	506,621	1,922,262	104,343	2,379	621,857	2,846,488
1995	130,271	32,674	169,945	3,556,445	1,053,245	4,609,690	101,806	24,604	1,011,855	5,917,900

[a] Estimates for all years were generated with the most current apportionment model and may differ from earlier estimates.

[b] Chinook salmon >655 mm.

[c] Chinook salmon ≤655 mm.

[d] This estimate may not include the entire run. However, in 2008 through 2013, operations were extended to September 7 instead of the usual end date of August 31.

[e] Includes sockeye salmon, cisco, whitefish, sheefish, burbot, longnose sucker, Dolly Varden, and northern pike.

[f] High water levels were experienced at Pilot Station; therefore, passage estimates are considered conservative.

[g] Estimates include extrapolations for the dates June 10 to June 18 to account for the time before the DIDSON was deployed.

[h] The Pilot Station sonar project did not operate at full capacity in 1996 and there are no passage estimates for this year.